# The Engineer

JUNE 15, 1956 — 28 ESSEX ST., STRAND, LONDON, W.C.2. — TWO SHILLINGS



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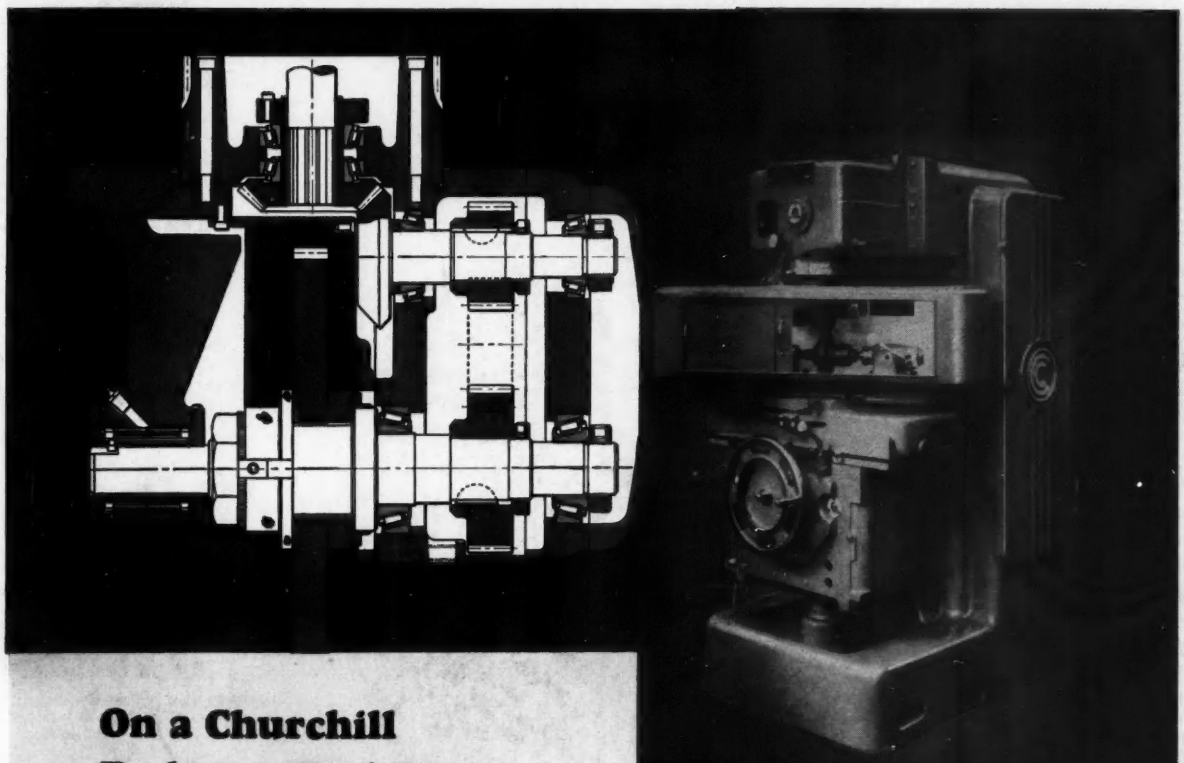

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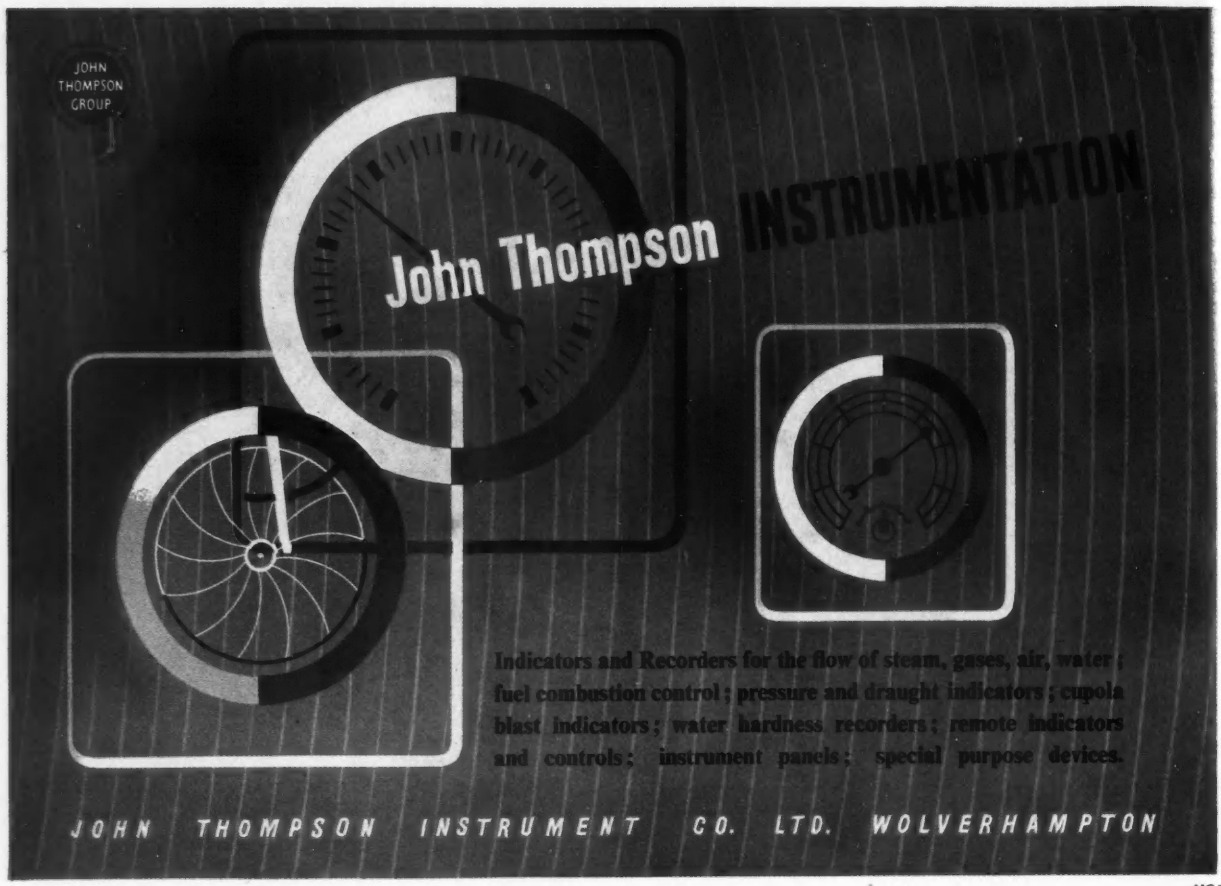
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INSET PLANT—

Sectional Arrangements of 200MW and 60MW Steam Turbines.


## TECHNOLOGY CHALLENGES SOVEREIGNTY

Again and again philosophers and statesmen, cartoonists and lampoonists have commented in their own ways about the effect upon mankind of the material enrichment brought about by technological advances. Are men being overwhelmed by machines ? Have they the slightest ability to make use of their new leisure ? Can they adapt themselves to such rapid advances? Are not neuroses caused by them? And so on. But in reality the effects of advancing technology are surely far more deeply influencing human affairs than the discussion of such lesser matters would suggest. For advancing technology has been attacking and must in future ever more formidably attack the very conceptions of nationhood and sovereignty. To look at a proposal as a politician or as a technologist is to view it from angles that are quite startlingly different. Politically seen, for example, there is the stuff of dynamite in the negotiations going forward between Egypt and the Sudan about the distribution of Nile waters, particularly when it is remembered that other territories, Abyssinia, Uganda, Kenya and the Belgian Congo have an interest in the waters of the Nile or its tributaries and that the United Kingdom, the United States and Russia are all only a little less directly concerned. Yet technologically considered, there is nothing in the matter to generate any heat at all! Any civil engineer called in to study the river basin as a whole and asked how best to make use of its waters, bearing in mind irrigation, water supply, power generation, and navigation, is capable, it is true, of offering a variety of answers. But those answers will vary only in accordance with the differing weights he assigns to the importance of the differing uses to which the water can be put. Not one of them will be influenced to the slightest degree by political factors and all, without exception, will offer much greater benefits *in toto* than any proposal coloured by politics.

Politics, local, national or international, are just about as immiscible with technology as water is with oil. For advancing technology constantly challenges the reality of the values we assign to sovereignty. What ! Shall this parish give up some of its power to rule its own affairs by accepting a piped water supply from a water company ? Never ! But all the parish is asked to give up is the weary labour of carrying buckets to and from the parish well ! Did London suffer when it lost some of its "sovereign" power by allowing power stations that once served London alone to be linked with the grid ? Loss indeed ! There was in fact a gain. When a number of councils combine to give up the treatment of sewage in the local works by the building of a single works taking the effluent from a wide area everyone gains by the "loss." In fact, as the technologist sees it, sovereignty is usually something diffuse and elusive that holds back advances which could confer great benefits on mankind. And is it not often true when we claim our sovereignty will suffer that what we really feel is a selfish fear that the other fellow, rather than ourselves, will get the greater benefit ? Or that we want jealously to preserve some special privilege for ourselves alone ? Often, if the advantages of the technological advance which can be made by combination are

taken into account, it proves a case of cutting off one's nose to spite the other fellow's face !

For ever, we suppose, politicians, local or national, who may fancy their own power or that of the peoples they represent likely to be whittled down by a loss of sovereignty, will oppose the larger schemes of engineers whose views are broader ; broader, not because they are better men, but because they see a problem technologically instead of politically. Fortunately, looking back on the history of engineering, there proves to be no ground for pessimism. It is remarkable how great schemes, often bitterly opposed at first, still in time get carried out. Around the parish pump it may be argued that " our " affairs cannot be placed under the control of the " aliens " in that village 3 miles away ; nationally it may be argued that " we " dare not link " our " destinies with the foreigners across the border. But, often at the expense of interminable delay, the logic of technology eventually triumphs. How comforting it is in a world living under the shadow of the hydrogen bomb to feel that the logic of technology does triumph ! For advancing technology knows nothing of artificial national boundaries. It " cocks a snook " at jealously guarded sovereignties. It more and more forcefully compels nations to co-operate and to fuse their destinies. Were there more men technologically trained amongst statesmen and politicians, we believe the process would be accelerated. We wish there were !

### CONTEST IN AIR TRANSPORT

The marked success in recent years of the turbine-propeller type of airliner, the " Viscount " especially, has certainly whetted the appetite of the air travelling public for even more of that high quality. That aircraft has been remarkable for its excellent performance on all medium-haul journeys. It has proved popular on account of its comfort, its reliability, its freedom from undue vibration and noise, and its excellent sustained speed. In due course it is, we are told, to have a successor which is to carry the adventurous name of " Vanguard," and this will, we hope, make an equally strong appeal to discriminating travellers. " Discriminating " is the natural word to employ, for we are told that there is to be an American vehicle bearing the same ambitious name, but this, it seems, is planned to do merely temporal duty as an earth satellite of modest size and is by no means for intending air travellers, who, indeed, might hardly be pleased to find themselves engaged in an unintended experiment in space travel, even within the limits of the solar system !

Since it seems that about 300 "Viscounts" have been, or are being, built, whilst it appears from Masefield's authoritative address to the last meeting of the British Association that the whole of the airliners in the world total only 3700, one can realise what a creditable share in that total is represented by this one product of the Vickers organisation; especially when of the world total of 4200 million ton-miles of air traffic in 1955 the American proportion is given as 60 per cent compared with Britain's modest share of seven. The airliner " Vanguard " is expected to carry about 100 passengers and be good for distances of 2500 miles with a cruising speed of 400 m.p.h., compared with the " Viscount's " 320. By then the Bristol " Britannia " will also be in world-wide service, and the two types should be able by their performances to show the world the high level of efficiency " turbo-props " can achieve. Nor will the British turbo-props be alone ; the Lockheed Aircraft Corporation has given the patronymic " Electra " to a four-turbine airliner of classical American conception and a performance comparable in speed, load and range, with that of a " Vanguard." Meanwhile, the " Viscount " may meet twin-engined competitors, since the General Dynamics Corporation is reported to be greatly interested in the installation of Napier " Eland " engines in its " Convair-Liner " ; since the piston-engined versions of this machine are well established, and the earning capacity would appear to increase with the power-weight ratio of the engines, it seems that only the capital costs of installing the British engines can prevent the turbine plant becoming widely adopted. However, the agreement between General Dynamics and the Bristol Aeroplane Company, that at least for the present " Convair " and " Canadair " shall not actively take part in constructing an airliner to excel the " Britannia," must retard the appearance of a really large turbo-prop airliner. As the present Minister of Supply has repeatedly observed, there are valid and immutable reasons why aircraft are developed more rapidly in the U.S.A. than here, and we can hardly expect a prototype to start its trials by flying the Atlantic east to west ! To engineers on both sides of the Atlantic it will be of immense interest to watch the contest for supremacy between the turbo-jet and the turbo-prop types ; the one expected to have the higher speed and the other to possess a more attractive thermal efficiency and greater economy.

The higher fuel consumption of the pure jet has led to the construction of air liners much larger than the " Britannia "—larger even than the " Brabazon." The astonishingly high performance expected of the Douglas " D.C.8 " and the Boeing " 707 " will set new and severe problems in air traffic control and airport procedure ; neither in the air nor on the ground can the operator allow such machines to waste even fractions of an hour. An aircraft that fits more easily into the existing pattern of operations is the unusual and attractive S.N.C.A.S.E. " Caravelle " ; the projected use of " Conway " by-pass engines on the Mk. II should result in competitive economy even over relatively short stages. The unconventional configuration of this machine is reflected in remarkably good single-engine take-off performance, and on both the European and North American continents it should find wide application.

Press statements carry news of a Washington conference arranged earlier in this year to give opportunity for a general discussion on the airport requirements which are desirable to meet the needs of large jet airliners ; one of the questions debated was the noise level reached when taking-off or landing—can it be made tolerable ? Another no less difficult question concerned the current risks of air collision in the neighbourhood of airports, with the alarming suggestion that already some of the major airlines were showing an average of no less than four " near misses " a day ! With airspeeds rising to as high a level as 600 m.p.h., such problems have somehow to be faced—but equally certainly they must somehow be solved. Already Douglas has published details of a jet thrust reversing device and Boeing announced a sound suppressor which, in conjunction with the higher rate of climb of the turbine machines, will give the noise levels of present machines over much smaller areas. Thrust losses promise to be tolerable and the reduced excitation of the structure and cabin may allow the weight increase to be accepted. The inadequacy of present air traffic control methods has been widely and vocally discussed in the U.S.A., where " automation " of ground-to-air communication by transponders and the tracking of commercial traffic by the anti-aircraft defence radar system are looked to for solutions. This contest for leadership in civil air transport will be indeed interesting to watch. Will one country more than another prove to be backing the better horse ? Britain has every reason to be proud of her progress with its present and coming types of turbines, especially in view of the qualities claimed for certain new kinds of engine such as the new Rolls-Royce " Tyne," with the remarkably high compression ratio of 12 : 1 and the low figure expected for fuel consumption. Experience so far suggests that since the turbo-prop will operate at the higher efficiency, and use an equally cheap form of fuel, it will have a marked advantage over its chief rival in running costs and this should go far to balance any disadvantage it may have in respect of air speed—though precisely how the balance sheet will work itself out has yet to be revealed.

# A Seven Day Journal

### Chemistry Research Board's Report

THE report of the Chemistry Research Board for 1955 has been published by H.M. Stationery Office and states that, because of the wide range of subjects in relation to available staff, only selected topics are dealt with. The close link with the U.K. Atomic Energy Authority is emphasised, some 25 per cent of the staff being engaged on work for this authority. Among the processes investigated by the Radio-Chemical Group, in its study of the extraction and concentration of metals, are those involving leaching followed by selective precipitation or recovery by ion-exchange or by solvent extraction. Another investigation involves the omission of the filtration step in the recovery of metal by adding a resin to the pulp of ore, and the report also mentions a process for the recovery of gold from cyanide solutions. This has shown that gold and silver can be selectively adsorbed from a gold mill pregnant liquor by weak base ion-exchange resins and then eluted by a reagent and finally recovered by electrolysis. The Inorganic Group notes the increasing attention paid to rare earths and reports that methods of separating the rare earths and of producing pure compounds are being studied. The research programme on semi-conductors, it is stated, has stimulated work on ultra-pure specimens of elements showing such properties, and methods of preparing these materials are being studied. The High Polymers Group comments that methods for separation using ion-exchange resins are often over-elaborate for qualitative analysis, and states that a simple method has been devised for preparing paper with ion-exchange properties in which finely divided ion-exchange resin is incorporated in the cellulose pulp. This paper, it is thought, can be used for the separation of mixtures of cations or anions using techniques employed in conventional paper chromatography. It is stated by the Microbiology Group that large quantities of available aromatic substances run to waste and that those used in sheep dips and plant control chemicals are broken down microbiologically during use and in the soil. More information on the bacterial breakdown processes, it is thought, would be of value to improve existing products.

### Productivity in Electro-Plating

FOR two or three years investigators of the British Non-Ferrous Metals Research Association have been visiting the plating shops of a number of electro-plating firms to study the methods employed and recommend possible improvements. Certain general conclusions and recommendations which originated in this work have now been incorporated in a survey of a cross section of the electro-plating industry by G. A. Edwards and E. A. Ollard, which is available from the Association at Euston Street, London, N.W.1, as Development Report No. 56. Twenty-nine shops were considered in compiling the report, almost all being manual, since automatic plants would be of less general interest. Subjects studied ranged from the layout of plant to the payment of employees. Many of the recommendations made, on the arrangement of equipment and the use of wire to support work, seem to suggest that superintendents were far from ambitious, and the report expects a worsening of the shortage of skilled labour, since only two of the firms ran apprenticeship schemes and they found it difficult to recruit candidates. Other criticisms reflect on the technology, frequently where nickel was being deposited; the "blinding in" of irregularities in particular was considered dangerous. The investigators could only judge visually the quality of the work produced, but considered that in many cases the work, even if looking well, was likely to fall short of customers' requirements.

## The Engineer
### 100 Years Ago
(JUNE 13, 1856)

"GOVERNMENT PATRONAGE AND SCIENCE"

"Whether there be any force or not in Professor Liebig's remark, that in England attention is almost exclusively paid to practical and in Germany to theoretical, science, one thing is perfectly clear, that for the scientific knowledge England as a nation possesses, it owes small thanks to the *State*. Perhaps of all the countries in the world, professing to rank among the foremost in civilisation and progress, England is indebted the least to the assistance and encouragement of the State for the position she occupies in the ranks of science, and for the ever-constant advancement she is making. It is quite true that as often as the subject is broached we hear of the Government grants to the Royal and other societies, and these grants are paraded with great show and circumstance as evidence of the paternal watchfulness of the State and of the disposition of the Government to foster science and encourage art. . . .

"We are not begrudging the paltry grants at present existing. The learned societies, thus endowed, are very well in their way; they want new vigour, doubtless; but we are disposed to regard them with profound respect, and the halo of motherly antiquity with which they are invested with a considerable amount of awe. . . . But we want something more than what we have got. There is a strong feeling in the minds of the people that genius is not encouraged in this country as in others—in France, for example. We will set aside from consideration the question of money grants; we know it is hard to say how such pecuniary aid can be applied to advantage; but why should not some order of merit be established in this country, some mark of honourable distinction, which could be bestowed upon those who have distinguished themselves in successful search after knowledge, or in the promulgation of discoveries of public or national value? Surely no one could be injured by this! Certainly, the consolidated fund would be no sufferer. But that there is a strong feeling upon the part of the ruling powers against this proposition is evident by the determination with which they resist all discussion on the subject."

### Water Pollution Research

THE Water Pollution Research Board has published its report for 1955; it reviews the first complete year's work which has been carried out in the new laboratory at Stevenage. With the facilities now available it has been possible for the organisation to collaborate much more closely than formerly with other bodies interested in the prevention of pollution. The laboratory's survey of the Thames estuary remains a work of considerable importance. In estimating the relative importance of polluting discharges the effect of rainfall has been found to be important. On one day of heavy rain, for example, the polluting load from storm water discharges was about one-fifth of the total load, whereas the average is only about 1 per cent. The final calculations on the effect of different factors on the state of oxygenation of the estuary are not yet finished, but calculations giving the effect of heated effluents on the distribution of temperature have been completed. There is quite good agreement between predicted and observed distribution of temperature. An investigation has also been begun on the effect of pollution, by effluents containing organic matter, on the oxygen content of streams. Further work carried out during the year has emphasised the important effect which the nature of the diluting water in the test for biochemical oxygen demand may have on the result obtained. For a given B.O.D. the ultimate demand may be much higher for a treated sewage effluent than for a diluted settled sewage. Laboratory experiments have been made with percolating filters ventilated with mixtures of oxygen and nitrogen in different proportions, for which it appears that the supply of oxygen by natural ventilation of a filter is not normally a factor which limits the rate at which sewage can be treated within the range of rates used at a sewage works. Some observations were made of the performance of an alternating double filtration plant treating sewage at Bedford. The average loading was 0·32 lb B.O.D. per cubic yard per day and effluents of very good quality were obtained. Work carried out during the year included studies with pilot plant on the biological destruction of cyanide, and with small-scale plant on the anaerobic digestion of meat wastes, the treatment of washing waters from cattle sheds, and the treatment of waste oil-in-water emulsions.

### Conference of Standards Officers

THE second annual conference of standards officers has been held recently in London. It was arranged jointly by the British Standards Institution and the Institution of Production Engineers, and brought together a company of engineers and other executives whose responsibility it is to apply standards in industry. A talk on "Standards, the Standards Engineer and Economic Production," was given at the conference by Professor H. W. Martin, of the Rensselaer Polytechnic Institute, New York. He spoke about the economic implications of standards engineering, and expressed the view that the standards officer's function came well within the sphere of top management—to bring control to bear on manufacturing processes, to eliminate wasteful work, and to raise productivity, thus making possible higher earnings for workers, executives and investors. Professor Martin emphasised that in assessing the value of standards it was essential to have a proper costing system. During the discussion which followed it was apparent that some of the standards officers present did not regard their work as including all the economic aspects outlined by Professor Martin. Many clearly believed that their task as engineers was to achieve simplification without too much concern as to the eventual profit and loss account. It became evident, too, that some managements tend to look on standardisation as imposing dull uniformity (and therefore threatening sales), a view which restricted the activities of their standards officers.

# Large High-Pressure High-Temperature Steam Turbines

By JOHN CALDWELL, B.Sc., Wh.Sc., A.M.I.Mech.E., A.F.R.Ae.S.*

*The demand for electrical energy is rising very rapidly in all countries. Easily developed hydraulic power sites are becoming rarer and supplies in the immediate future must come more and more from thermal stations using either fossilised or atomic fuels. Great economies result if power is produced in large blocks, and the steam turbine continues to demonstrate its remarkable capacity for development to meet this need. In this article a brief account is given of some of the problems which the development of large turbines has raised, together with a description of some of the features of the first 200MW steam turbine which will be installed in Britain.*

THE continuing rise in the costs of fuel and labour and the shortage of both have created an intense demand for electrical generating stations showing the highest possible efficiency and ease of operation. There are no signs of any slackening of this trend, which has been a feature of the power field since the end of the 1939–45 war.

It has long been known that, for the greatest efficiency in converting the heat energy available in fuel into useful power, the thermodynamic cycle used should employ high initial temperature, and to develop the power from high-temperature steam high initial pressure is also necessary. Thus, while the general level of steam conditions in use in Britain in 1945 was about 650 lb per square inch inlet steam pressure with a temperature of 825 deg. Fah., current designs, in seeking for improved efficiency, range around 2000 lb to 5000 lb per square inch and temperatures of 1000 deg. to 1200 deg. Fah. Further thermodynamic advantage can be gained, if the steam is returned after partial expansion to the boiler for reheating to a temperature approaching the initial value, before it continues to expand through the turbine down to the condenser pressure.

Advanced conditions like these can, in theory, be used on any size of set, but the need for larger running clearances in higher temperature turbines and the tendency towards greater leakage losses at higher pressures suggests the use of advanced steam conditions on sets of large output only. Here the main flow in the blade and nozzle passages is so great that the relative importance of leakage effects and other losses arising with shorter blades is reduced to an acceptable level. In other words, if too advanced conditions are specified for a turbo-generator of relatively small output, the turbine efficiency, as a hydraulic machine, suffers unduly and part of the gain secured from advancing the cycle conditions will be lost in leakage and other hydraulic losses in the turbine.

It is partly for this reason that the size of unit has increased over the past ten years, in line with the stepping-up of steam conditions mentioned above. In 1945 turbo-generators in use in Britain were commonly about 30MW capacity and the design of 60MW sets had just begun. To-day units of 200MW output are already in manufacture and still larger sizes are being considered. The demand for these greater capacities in one unit arises, not only from the efficiency considerations indicated, but, in addition, because they are more economical in first cost and in operating personnel required per kilowatt. This is just as important as a gain in efficiency, since, in the long run, the criterion of economical power generation is lowest possible overall cost in producing a unit of electricity.

It might appear, in setting out to generate power in units of such large size, that the old mistake of "too many eggs in one basket" was being made, since if a 200MW unit in Britain goes out of commission for any reason the loss in electrical output under base load conditions amounts in terms of money to about £10,000 per day. However, developments in other branches of technology, particularly instrumentation and electronics, have made it possible to give the supervising personnel centralised means of control and much more detailed information about the minute-to-minute running of the plant under their care. The cost of such supervisory equipment is very little in relation to the overall cost of the plant, and its introduction has greatly increased the safety of operation of such large sets.

In what follows some aspects of the problems in the design of these large units will be exhibited. Modern steam plant in power stations is so extensive that it would require many articles to cover every feature and in what follows discussion will be confined almost entirely to the turbines.

## Typical Turbine Sectional Arrangements

Designs characteristic of the development of large steam turbines of ten years ago and to-day are shown on the drawings inset between pages 666 and 667. These machines develop 60MW and 200MW under the steam conditions listed in Table I. The drawings are to the same scale and it will be seen that the increased power has been obtained for an increase of only 6ft in the overall turbine length.

Table I

| | | |
|---|---|---|
| Output, MW | 60 | 200 |
| Inlet steam : | | |
| Pressure, lb per sq. in. g. | 900 | 2,350 |
| Temperature, deg. Fah. | 900 | 1,050 |
| Reheat steam : | | |
| Pressure, lb per sq. in. abs. | — | 441 |
| Temperature, deg. Fah. | — | 1,000 |
| Feed heating : | | |
| Number of stages | 5 | 6 |
| Final feed temperature, deg. Fah. | 385 | 460 |
| Vacuum, in, Hg. | 28·7 | 28·7 |

It will be noted, however, that the layout of the steam paths and the mechanical design of the turbine have undergone quite radical changes in producing the 200MW design.

In the 60MW set each rotor has its own thrust block and is coupled to its neighbours by flexible couplings permitting independent axial movement. A straightforward path is provided for the steam through the three cylinders, from the inlet to the high-pressure cylinder to the twin-flow exhausts to the condenser after the double-flow low-pressure cylinder.

The 200MW set has, on the other hand, solid coupling of all steam rotors to one another and to the alternator. One block takes the combined thrusts of all rotors, and axial clearances between rotors and casings have to be designed to take care of any accumulated thermal movement of rotors coupled in this way. By placing the thrust between the h.p. and i.p. cylinders the problem of providing clearances to take care of axial expansion is greatly reduced and to some extent the overall steam thrust can be balanced out.

On the 200MW set the steam enters the nozzle chamber in the h.p. cylinder through two pipes in the middle of its length and flows through eight stages of impulse blading towards the non-driving end of the set, these stages being accommodated in an inner casing. Leaving this casing, the steam has a pressure of 837 lb per square inch and a temperature of 793 deg. Fah. and returns to the middle of the cylinder by flowing between the inner and outer casings. From here it continues its expansion through four further stages of impulse blading to the end of the h.p. cylinder nearer the alternator. At this point the steam temperature and pressure have fallen to 667 deg. Fah. and 490 lb per square inch absolute respectively, and on leaving the cylinder the steam is passed through two pipes of 18in bore to the reheater section of the boiler. It returns to the turbine through two pipes of 18in diameter, passing through the reheat emergency stop and interceptor valves to enter the i.p. cylinder with a pressure of 430 lb per square inch absolute and a temperature of 999 deg. Fah.

The intermediate-pressure cylinder has an inner casing housing three of the eight stages of impulse blading. It will be seen from the section drawing that the i.p. rotor and one rotor of the three l.p. expansions are combined into one shaft, with a belt between the two groups of blading for leading off steam at 52 lb per square inch absolute and 515 deg. Fah. to the other two l.p. expansions. Bleeding of steam for the lower stages of feed heating takes place from the twin-flow l.p. expansions only, no steam being withdrawn from the l.p. expansion in the i.p./l.p. cylinder. All three l.p. expansions exhaust into a common exhaust chamber and single shell condenser at a vacuum of 28·7in Hg.

## Blade and Nozzle Design

In a turbine with such a range of steam conditions, the design of the running blades varies enormously from one end of the set to the other. High efficiency and safety in running are the prime requirements applicable to all stages. For this reason every stage has full steam admission at all times, even when one set of main or reheat admission valves is closed during a check on the freedom of movement of all valves. Avoidance of partial admission, particularly in stages where the steam is of high density and temperature, reduces very considerably the danger of failure arising from severe fatigue stresses being imposed on blade material working under temperature conditions causing creep.

On the long l.p. blading, on the other hand, root stresses due to centrifugal loading reach 17½ tons per square inch even when the blade section is tapered down severely from root to tip. In the presence of such a high mean stress and the wet conditions of operation, the fatigue resistance of the blade material may be reduced to about one-half to one-third of the dry endurance limit under zero mean stress. It is highly important, therefore, to ensure that excitation of vibration in the blading cannot easily occur.

In Fig. 1 we show blading of the design used for the exhaust stages of the 200MW turbine mounted for a series of test runs under vacuum up to speeds of 3500 r.p.m.

* Steam Turbine Division, The English Electric Company, Ltd., Rugby.

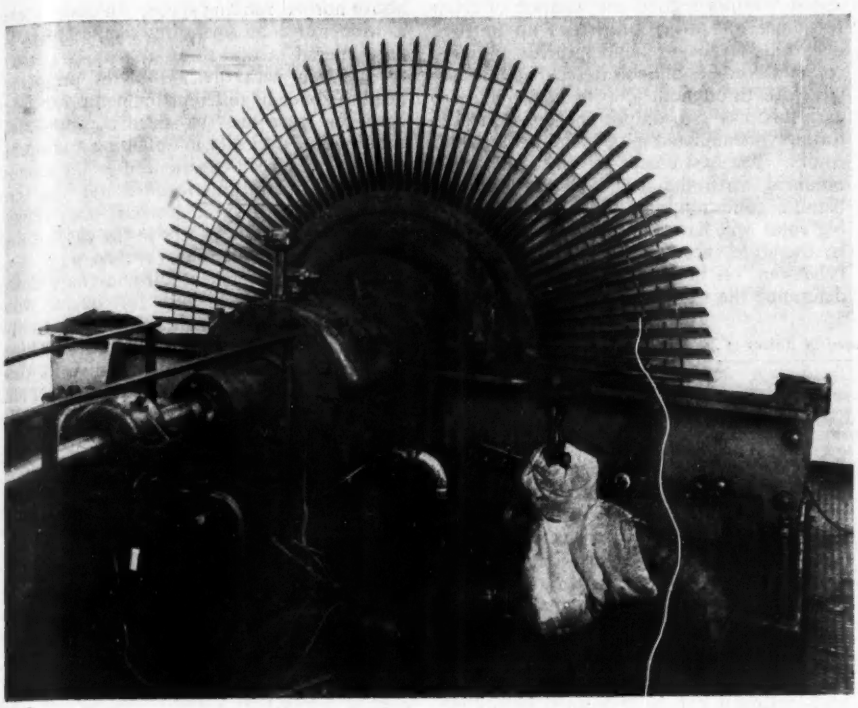


Fig. 1—L.P. blading of the design used for exhaust stages of 200MW turbine. It is being erected here for a series of tests under vacuum at speeds up to 3500 r.p.m.

In these tests steam jets are adjusted to play on the blading with varying intensity, direction and point of application. In this way it is demonstrated that the blading, which has an active length of 27in and is stiffened by three rows of lacing wire or tube, can give only a weak response to heavy exciting forces. In the turbine itself, naturally, every care is taken to ensure that the steam flow from the stationary nozzles is uniform.

Over the past twenty-five years much work has been done to investigate the flow in turbine blading. Much of the earlier testing is now known to be of little value, because the appropriate similarity conditions between the turbine and the test blading were not fully satisfied. Recently a variable-density tunnel, using air as the testing medium and covering fully the range of Mach and Reynolds numbers encountered in steam and gas turbines, has been put into operation at Rugby. An external view of the tunnel shell and the operating panel is shown in Fig. 2. Fig. 3 shows a schlieren photograph, taken in the tunnel, of the flow through a nozzle in which a local Mach number of about 1·5 is reached near the trailing edge of the blade on the convex side. A similar photograph for $M=1$ is shown on the right (Fig. 4).

Air turbines are likewise very useful for bringing out details of the flow not fully reproducible in static blade tests. Recent work has shown, after a long series of tests, that there is little to choose, from the point of view of sound three-dimensional flow, between various forms of vortex blade so long as a condition of recompression of the steam at the root section of the moving blade is avoided.

Before passing on to other topics, it may be worth while mentioning a point which is not always realised but which is of obvious importance. As inlet pressures rise in the newer sets, so do the pressure drops in the early stages, and this is of considerable importance, when thrust calculations are being made, particularly if balancing of one rotor thrust against another is used to some extent to get the overall thrust down to a convenient value. Extra care is required in assessing the exact pressure distribution on the blading and discs of these high-pressure stages.

This has a connection with an operational difficulty in the early life of a new set, where debris is only too often brought over by the steam, because the boiler and main piping have not been sufficiently cleared of weld pellets, scale, &c. This material, in spite of the use of strainers, frequently causes much damage to the turbine blading, and the restriction on flow areas in these early stages with high designed pressure drops may cause thrusts to build up to much higher values than those calculated in design.

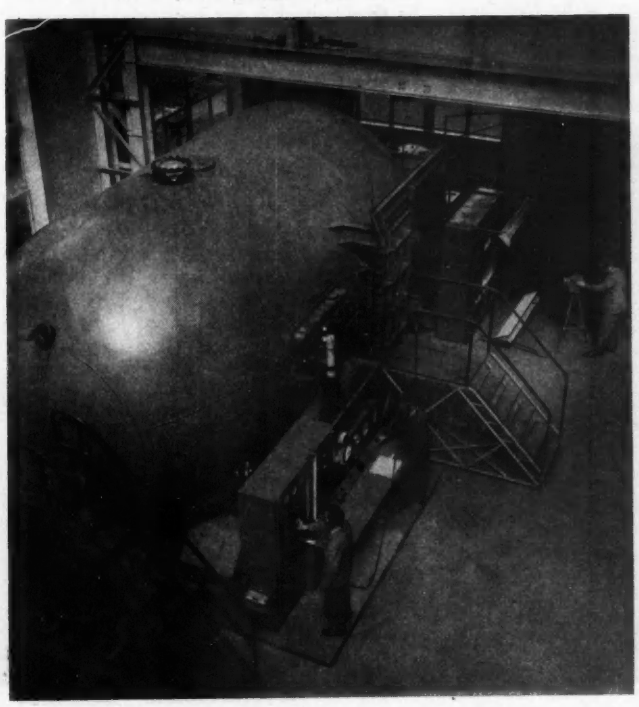


Fig. 2—Variable density wind tunnel for experimental work on steam turbine and gas turbine blading

### Diaphragms

The high pressure drops in the early stages of high-pressure turbines have been mentioned above. In the sectional drawing of the 200MW turbine this is reflected in the unusually thick diaphragms.

When creep is mentioned in steam turbines, blading and rotors are usually spoken of as showing the most pronounced effects. In practice, diaphragms have shown much more sensitivity to creep. Carbon steel diaphragms of very small elastic axial deflection have, in fact, shown permanent axial distortion, due to creep effects at a temperature as low as 600 deg. Fah. This arises from two causes. Stresses in diaphragms are not easily calculated with accuracy, and, moreover, comparatively small compressive and tensile creep strains on the two sides of the diaphragm can produce quite marked permanent axial deflections due to creep. Whereas a restriction on creep strain to no more than 0·1 per cent in 100,000 hours is regarded as reasonable for rotors and blading, experience would suggest that the figure for diaphragms should be of the order of one-hundredth of this or less. With existing ferritic materials this implies the use of very low working stresses in bending in the diaphragm centre and rim and correspondingly great thicknesses.

It will be clear also that it is difficult to gain knowledge of suitable diaphragm materials from creep testing. The creep rates which can be used in design are so low that it would be difficult to maintain sufficient accuracy of measurement over the long testing times which are required.

An alternative to a thick ferritic diaphragm is one made in austenitic material of increased creep strength, but this has a higher coefficient of thermal expansion which inevitably introduces further design problems.

If better ferritic materials cannot be produced, a third alternative might be to regard diaphragms as a turbine component requiring maintenance or even replacement at definite time intervals. There is little danger of rupture of a diaphragm, because the creep rate is so low and any attention required could be given to the diaphragm during the planned overhaul outage of the set.

### Rotors

The h.p. and i.p. rotors of the 200MW turbine operate under maximum temperatures of about 1000 deg. Fah. and are of solid construction with gashed discs. This has been recognised as good practice for many years, since a high range of temperature change during starting and other operating conditions would lead to undesirably great thermal expansion movements

in a rotor consisting of a shaft and mounted discs.

In the low-temperature region, where diameters are large and blades are long, the high centrifugal stresses developed in the discs make it difficult to obtain solid forgings of sufficient strength. Disc forgings in high quality material are more easily obtained and this leads to a preference for low-pressure rotors of built-up construction in which large discs are mounted on a shaft forging. The hub width required in the discs is higher than the corresponding disc pitching in a solid forging, so a price is paid in extra shaft length. In the 200MW design it will be noted that the i.p. rotor is of solid construction but that the discs of one l.p. flow are mounted on the same shaft. The materials employed in these rotors and their properties are stated in Table II.

TABLE II.—*Properties of Materials used in Rotors of 200MW Turbines*

| Rotor | Type of steel, Per cent | | | | | | | | | Mechanical properties, tons per square inch | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | C | Si | Mn | S | P | Mo | Va | Ni | Cr | Ultimate | Yield* | Creep† |
| High-pressure and intermediate-pressure shafts | 0·25 max. | 0·35 max. | 0·4 to 0·7 | 0·04 max. | 0·04 max. | 0·50 to 0·85 | 0·25 to 0·40 | 0·50 max. | 0·60 max. | 40 min. | 25 min. | 4 |
| Low-pressure shaft | 0·35 to 0·40 | 0·20 to 0·25 | 0·6 to 0·9 | 0·04 max. | 0·04 max. | — | — | 0·30 max. | — | 38 | 20 | — |
| Low-pressure discs | 0·3 to 0·4 | 0·35 max. | 0·60 to 0·90 | 0·04 max. | 0·04 max. | 0·5 to 0·7 max. | — | 0·5 max. | 3·0 to 3·5 max. | 55 min. | 45 min. | — |

* Ultimate and yield strengths quoted are at room temperature.
† Creep strength quoted is for 0·1 per cent strain in 100,000 hours at 1000 deg. Fah

Advances in large steam turbine design are greatly retarded by the absence of forgings in large sizes giving marked improvement in mechanical properties on those listed. A cautionary note has been sounded recently by the discovery in the U.S.A. and in Britain of forging defects in large rotors which had been involved in accidents to steam turbo-alternators.†

Creep is a factor of decisive importance in designs where the rotors are exposed to temperatures of 800 deg. Fah. or above. Molybdenum and more particularly molybdenum-vanadium steels with appropriate heat-treatment are already in service and appear to offer a good combination of creep resistance and other properties up to 1000 deg. Fah. exposure temperature. In large rotors it becomes difficult to secure a uniform structure throughout during heat-treatment and this has two important consequences for molybdenum and molybdenum-vanadium rotors. The best creep resisting structure is obtained when the steel is in the tempered bainitic condition, but large portions of a big rotor will have a pearlitic structure. It is, therefore, necessary to know the creep behaviour of both kinds of structure to determine the safe stress at which the rotor material can be worked. More uniform heat-treatment can be promoted by adding chromium to the alloy and by rotating the forging during the heat-treatment operation.

A further disadvantage of these steels arises from the possibility of this difference in structure not being symmetrically distributed in relation to the rotor axis. Slight differences of thermal expansion coefficient in the two kinds of structure may then give rise to differences of expansion on opposite sides of a rotor, the resulting bend, when it is hot, putting the rotor out of balance sufficiently for rough running to result. Thermal stability checks should, therefore, be made, before the rotors are bladed, to ensure the absence of such effects.

These checks are usually made with the rotor turning at about 2 r.p.m. in a heated oven, indicators recording any eccentric shaft movement resulting from a thermal bend. In recent times it has become customary in the U.S.A. to carry out corresponding tests at temperatures in excess of running temperature and at speeds up to 15 per cent above normal running speed. In cases where a wide range of operating temperatures is encountered in one rotor, it may be placed in an oven with division plates providing heating zones of different temperature. The need for these tests at speed suggests that considerable difficulty in obtaining a uniform structure has been experienced in the manufacture of these American rotors. So far, hot balancing at speed has not been found necessary in Britain except in the case of the relatively flexible alternator rotors.

The advent of reheat turbines has, however, indicated the need for ovens with different temperature zones for heat stability checking, and the i.p./l.p. rotor of the 200MW turbine illustrated will have its two ends subjected to such tests at 1100 deg. Fah. and 600 deg. Fah., respectively, while rotating at 2 r.p.m.

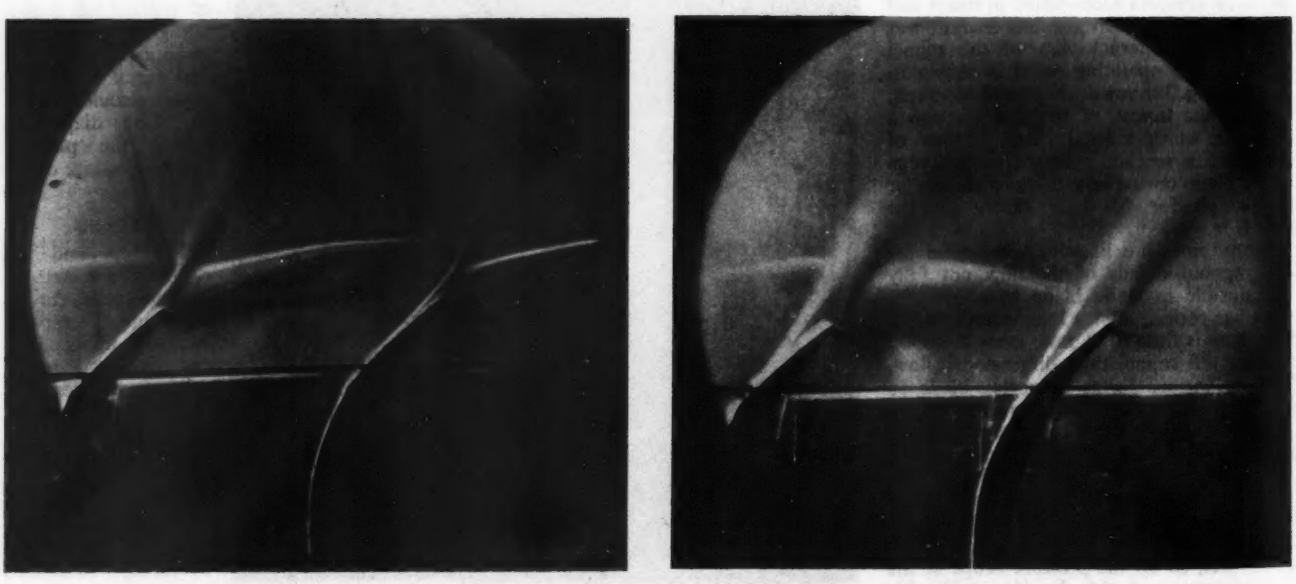
As steam temperatures are raised, the effect of stress and temperature on rotor and casing distortions must be more and more carefully assessed. Factors of safety comfortably obtainable with the materials and temperatures in use ten years ago can only be retained by special efforts on the part of the designer. Double casings offer a way out in casing design, but for rotors there appears to be no choice other than a change of material or designs embodying steam cooling applied to a rotor material already well proven at lower temperatures.

The maximum steam temperature in large British designs has kept constant over the past six years; there are sets of 60MW, 100MW, 120MW and 200MW capacity in operation or manufacture, all working at the maximum temperature so far employed —1050 deg. Fah. But there are signs of a desire for a change to 1100 deg. Fah. or possibly 1150 deg. Fah. The real significance of such a small step in temperature as 50 deg. Fah. is fully apparent only to engineers who are trying to circumvent its consequences, since it can halve the stress levels which may be employed at these temperatures.

Real difficulties arise as a result of the absence of long-term tests applicable to new steels, and this is often made worse by conflict in the evidence regarding the same material produced by different steel makers or test laboratories.

For an exposure temperature of 1000 deg. Fah. a 0·5 per cent molybdenum-vanadium

† *A.S.M.E.* paper 55-A-172. "Investigation of Large Steam Turbine Spindle Failure." H. D. Emmert. *A.S.M.E.* paper 55-A-208. "Report of the Investigation of Two Generator Rotor Fractures," C. Schabtach, A. W. Rankin, E. L. Fogelman, D. H. Winne.



Figs. 3 and 4—Schlieren photographs of flow through a nozzle. (Left) A Mach number of about 1·5 is reached locally near the trailing edge of the blade on the convex side. M=1·24 after shock equalisation. (Right) A similar photograph showing conditions where M=1

steel will take a stress of 4 tons per square inch for 0·1 per cent strain in 100,000 hours. It would appear that the same level of stress should be obtainable at 1050 deg. Fah. exposure from a steel containing about 1 per cent Cr, 1 to 1·25 per cent Mo, and 0·2 to 0·3 per cent Va. An alternative choice is a steel containing 0·2 per cent C, 12 to 14 per cent Cr, 1·00 per cent Mo, and a wheel of this material appears to be in operation on a radial-flow turbine in Germany,‡ with an inlet steam temperature of 1130 deg. Fah.

For higher temperatures of exposure around 1100 deg. Fah., cooled ferritic rotors or austenitic material of the 18 per cent Cr, 10 per cent Ni, 1 per cent Cb type are under consideration. These austenitic steels may, however, be more prone to thermal instability than the ferritic materials. They exhibit unwelcome thermal effects generally to a greater degree than ferritic rotors.

In assessing a new material for its suitability for application at the above temperatures, a factor which is becoming of considerable importance is the resistance of the steel to oxidation. At 1050 deg. Fah. molybdenum-vanadium steel already shows signs of scaling ; the 12 per cent Cr material has good scaling resistance, but above 1100 deg. Fah. austenitic steels appear to be necessary to give the required strengths against both creep and scaling.

## Turbine Casings

Two main problems arise in connection with casings for large high-pressure, high-temperature turbines employing reheat. In the first place, the point at which steam is to be taken from the turbine for reheating and the point to which it is returned at the higher temperature must be settled. Secondly, the high-pressure loads on cylinder joint flanges, associated with the low permissible bolting stresses determined by the high prevailing temperatures, present very awkward problems in the design of the flange bolting.

Generally, it is simpler to expand the steam to the reheating pressure in one cylinder as shown in the sectional drawing and to take it on return from the reheater through the emergency stop and interceptor valves to the inlet to a second cylinder. In other cases it may be preferable to return the reheated steam to a different part of the cylinder which it originally left. It will be obvious that very close consideration must be given to avoiding so far as possible sharp temperature gradients in a cylinder, so that it can be stated quite generally that returning the resuperheated steam to a point close to where it left the cylinder is inadvisable.

The bolting problem can be greatly reduced by the adoption of a double casing construction. This helps in two ways. The inner casing which has to take high internal pressures is then subjected to quite large external pressure also, instead of to atmospheric pressure as in a single casing design. This greatly reduces the pressure difference on which the inner casing and its flange bolting must be designed, and simultaneously the temperature difference across the inner casing is decreased.

The inner casing need not be carried the full length of the outer casing, since the stage pressure drops for a given heat drop are very large with steam of such high density. Thus, after a few stages of expansion the pressure falls to an acceptable level for a single casing. Advantage is taken of this fact in the 200MW design to place the high-temperature steam inlet in the middle of the outer cylinder. The exhaust steam from the inner casing returns along the outside of the latter, cooling the inlet piping on the way, thus easing the mechanical design of this connection.

The inlet pipes to the h.p. cylinder of the 200MW set are four in number, but are interconnected in pairs just before entering the casing radially at top and bottom. The pipes at their other end are connected in diagonally opposite pairs to two steam chests. The inner casing is located by suitable guides in the plane of steam admission. The inlet piping slides in a piston ring telescopic joint in the inner casing, thus taking care of differences of radial expansion between outer and inner casings. The piping is also hotter than the outer casing and differential radial expansion is allowed for by the flexible collar shown.

The intermediate pressure cylinder shown in the drawing is also arranged as a double casing construction at the high-pressure end. Steam is fed into the nozzle chamber via four radial pipes as shown in the section, Fig. 5. These flanged pipes are inserted

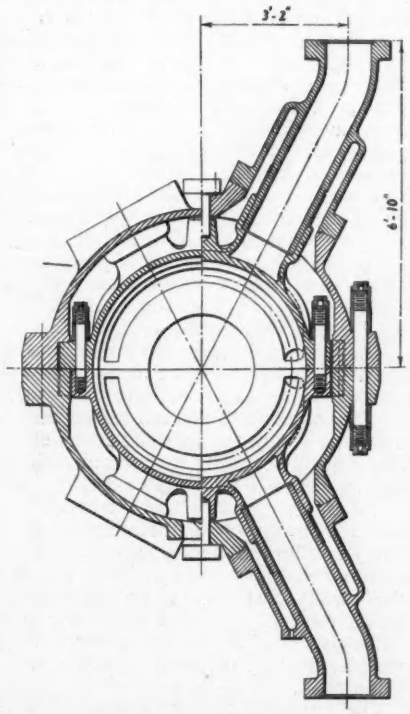



**Fig. 5—Radial pipes for steam feed to intermediate pressure cylinder**

radially, after the inner casing has been centred within the outer and the top half of the outer casing has been placed in position.

In a reheat set the steam has only about 6 per cent to 8 per cent wetness on reaching the condenser, and it is normally hotter at inlet to the low-pressure rotors than in a non-reheat set. Consequently the low-pressure casings which carry the fixed blading are cast in steel instead of iron. The exhaust chamber is so large that it will require to be manufactured in several pieces and seal-welded after erection at site.

Similar size problems arise in dealing with the condenser shell.

The h.p. and i.p. outer casings are of molybdenum-vanadium steel castings, the corresponding inner casings being cast in chrome - molybdenum - vanadium - tungsten. The compositions are as shown in Table III.

Table III.—*Composition of H.P. and I.P. Inner and Outer Casings*

| Casing | C | Si | Mn | Ni | Cr | Mo | S | P | Va | W |
|---|---|---|---|---|---|---|---|---|---|---|
| H.P. and I.P. outer ... ... ... ... | Per cent 0·15 max. | Per cent 0·2 to 0·5 | Per cent 0·4 to 0·7 | Per cent 0·3 max. | Per cent 0·5 max. | Per cent 0·5 to 0·7 | Per cent 0·05 max. | Per cent 0·05 max. | Per cent 0·20 min. | Per cent — |
| H.P. and I.P. inner ... ... ... ... | 0·16 max. | 0·4 max. | 0·4 to 0·6 | 0·5 max. | 2·75 to 3·25 | 0·5 to 0·7 | 0·05 max. | 0·05 max. | 0·7 to 0·9 | 0·4 to 0·6 |

## Shaft Couplings

Turbines of British manufacture have generally incorporated flexible couplings of various kinds to transmit the power from the rotors to the generator. With this construction individual adjustment of the end clearances of each rotor is possible and a certain degree of relative misalignment of rotors is also permissible.

As sets have increased in output the torque on these couplings has gone up. In spite of the increased size of couplings the specific loading on the coupling teeth or claws has tended to increase. This increase of tooth pressure appears to have made relative sliding movement of rotors within these couplings more difficult. In any event, of recent years a tendency for restriction of axial rotor movement has been noticed more than formerly. This may be merely a consequence of fitting these larger turbo-generators with supervisory gear which shows up clearly the relative movements of rotors within their casings. The tendency to restrict relative movement may in fact always have been present.

The result of these observations has been to promote a change in design towards solid construction for some of the more heavily loaded couplings, and it would appear that eventually all large turbines may have solid couplings throughout.

## Shaft Critical Speeds and Alignment

With solidly coupled rotors the shaft system consists of a continuous beam over multiple supports, the reaction at which is influenced by the relative level of the bearings and the stiffness of the oil films formed therein under running conditions.

The possible change of shaft alignment and the shaft reactions have to be examined to ensure what degree of foundation settlement is permissible without dangerous stresses arising. As these stresses are fluctuating the possibility of fatigue in the shaft has to be kept in the forefront. In this respect it is essential that the ferro-concrete turbine blocks are on foundations which will not cause trouble through differential settlement. Several cases have occurred recently where such foundation settlement has upset the alignment of the turbine, which required repeated correction as settlement increased.

A further problem arises with such long shafts in that the methods used for calculating individual critical speeds of single-span shafts are too tedious and inaccurate to apply to the case of several solidly coupled spans. Fortunately a tool is ready to hand which enables this problem to be dealt with. By using classical theory for the dynamics of a shaft vibrating at its critical speed, but

‡ *Metal Progress*, January, 1954, page 116, Buchholtz, Ruttmann, Schinn, "Metallic Materials for a Steam Power Plant Operating at 1130 deg. Fah."

casting the equations in a form which can be digested by a modern electronic computer, it is possible to obtain in a few days answers to this problem which might otherwise take one man over a year to solve accurately, using an ordinary calculating machine.

One difficulty here is that, since any one rotor is only part of the system, it is not so easy to shift a critical speed to a value acceptable for running by merely changing the dimensions of one of the solidly coupled rotors. It is all the more necessary, therefore, to get the critical speeds correctly determined at an early stage in design, since they cannot easily be altered afterwards without wide-reaching modifications to several of the rotors.

### Steam Chests and Valves

Each of the main steam chests contains a combined stop and emergency valve which can be operated locally or from the control room, and closed by the action of various automatic and hand-tripping devices. The steam then flows in parallel through two single-seated throttle valves in each chest, one of the valves being almost fully open before the other starts to lift. The steam then passes to the h.p. cylinder through the 6in bore loop pipes mentioned above. The steam chests for the reheated steam each contain an emergency stop valve of the flap type as well as a single-seated interceptor valve with balance piston.

In the days of lower pressure and temperature it was quite common to have the governing valves in chests built as an integral part of the turbine casings, thus giving a very compact design with small volumes of relatively low-energy steam between the control valves and the first stage nozzles. This helped prompt checking of the speed rise of the set should it experience a sudden reduction of the electrical load. As initial steam pressures and temperatures have increased, designers have been obliged to adopt separate steam chests, which are usually mounted close to the machine but on separate foundation supports. This separation simplifies the cylinder casting and greatly helps in obtaining sound metal.§ If integral chests are retained together with some degree of nozzle control governing, unequal heating of the cylinder may be serious enough to cause casing distortion and interfere with the running of the set.

With separate chests and simplified cylinder castings the distortion problem is greatly eased, but the connecting piping between the chests and the casing must be in the form of long U-loops to give enough flexibility to minimise the thrust loads on the turbine. These pipes form reservoirs of high-energy steam beyond the control of the governing valves, which, together with steam stored in spaces in the casings, tends to increase quite seriously the problem of getting sufficiently rapid closure of the valves to check speed rise following a sudden loss of load. The time of closure of the valves must be reduced to a fraction of a second and the valves, when closed, must be practically tight, as even a small leakage of high density steam would feed enough energy to the turbine, when unsynchronised and at zero electrical load, to cause it gradually to overspeed to the point where the overspeed governor would trip the emergency stop valves.

This need for rapid valve closure is made still greater in large modern sets by the following trend. As the output of a set increases for a fixed speed, say, 3000 r.p.m., the torque from the turbine rises, but the overall dimensions of the sets only increase slightly, since the extra output is obtained by using more dense steam of higher initial heat energy. Thus, while the steam torque increases directly with the output of the turbine, the moment of inertia of turbine and alternator rotors increases only slightly. Hence, if full load is lost and the steam valves remain open for a short period, the full steam torque applied to relatively light rotors will cause overspeeding at the initial rate of 8 to 15 per cent of running speed in one second. Only by ensuring definite valve closure in much less time than one second can these overspeeding effects be kept in check, and the governors with their relays and servomotors must be designed accordingly.

In the past, double-seated control valves found much favour because the balance of steam forces achieved by double seating gave a light, responsive control. At higher temperatures, while such balance is still desirable and can be achieved, the differential expansions between the valve and its seat resulting from the increased temperature have brought double-seated valves into a certain amount of disfavour. It is difficult to ensure, even with valves and seat cages of nominally the same material, that the coefficients of expansion are in fact the same and, if this is not so, the seats which are aligned to give simultaneous closure when cold can easily be in error sufficiently at working temperature to prevent full closure on one seat, the resulting leakage of high density steam then producing control difficulties. For these reasons stop valves are almost invariably single-seating and the same tendency is now evident in governing valves.

A further difficulty with valves, particularly in the early life of a new turbine, arises from carry-over of foreign matter in the steam. Nearly all high-pressure, high-temperature joints in the boiler and the steam piping are made by welding, and this appears to lead to the carry-over of weld pellets, scale and other debris with the steam. To guard against this contingency, temporary strainers with holes of only about $\frac{1}{4}$in diameter are fitted in the steam piping ahead of the valves during early commissioning of the sets, whereas in normal operation strainers with holes $\frac{1}{16}$in diameter are employed.

The finer strainers in the earlier runs do catch much of the more easily dislodged matter but, unfortunately, they also restrict the flow of steam so that full load cannot be obtained. Thus, the sweeping action of full load flow is not really experienced until the normal strainers are put into service. For this and other reasons metallic debris continues to come over with the steam during the first year of operation of a new set and as the valve opening areas at light loads are relatively small, there are times when some of this debris becomes trapped in the valve seats and causes considerable mechanical damage, resulting in lack of steam tightness as the valves close.

The steam forces on a partly opened governing valve are heavy and tend to fluctuate violently. If the spindle or its guide is worn the forces cause the valve to hammer about and the spindle breaks by fatigue. The best safeguard against such defects is to reduce wear effectively by hardening spindle and guide bush surfaces, since lubrication at this point is impossible. Nitriding of the surfaces of these parts has proved effective at temperatures up to 950 deg. Fah. The benefit of nitriding is believed to deteriorate on prolonged exposure to temperatures greater than this, but practical experience at such temperatures is at present insufficient to confirm whether this is so or not.

So far, mention has been made only of the stop valve and governing valves at the inlet to the h.p. cylinder. The flow of reheated steam is normally controlled by these valves also, since, apart possibly from some extraction for feed heating, the steam quantity passing through the reheater is the same as that entering the turbine. However, the reheater tubing is long, as is the piping between the reheater headers and the boiler, the pressure is still quite high, about 400lb to 700 lb per square inch, and the quantity and energy of the steam stored in this volume is very considerable. This stored energy could, by itself, cause overspeeding to about 60 per cent beyond normal speed, if electrical load were suddenly removed. Since this steam has already passed beyond the control of the inlet governing valves it must under such conditions be prevented from causing overspeed, by fitting interceptor valves at the point where the reheated steam re-enters the turbine.

These interceptor valves are not governing valves in the sense that they are not required to control the flow of steam to the set, when the load is being increased or decreased at a steady controlled rate. They are normally fully open and only begin to close after a small fixed rise in speed above normal has occurred. Once closure begins it proceeds rapidly and the overall time of closure of the reheat valves has to be even less than that of the main governing valves. Just as emergency stop valves are fitted at the inlet to the turbine to act as a second line of defence should the governing valves stick or for any other reason be slow in checking speed rise, experience has shown that it is advisable to reinforce the protection afforded by the interceptor valves by including reheat emergency stop valves. These valves are under the control of the overspeed governor and other emergency devices available to the turbine and control room operators.

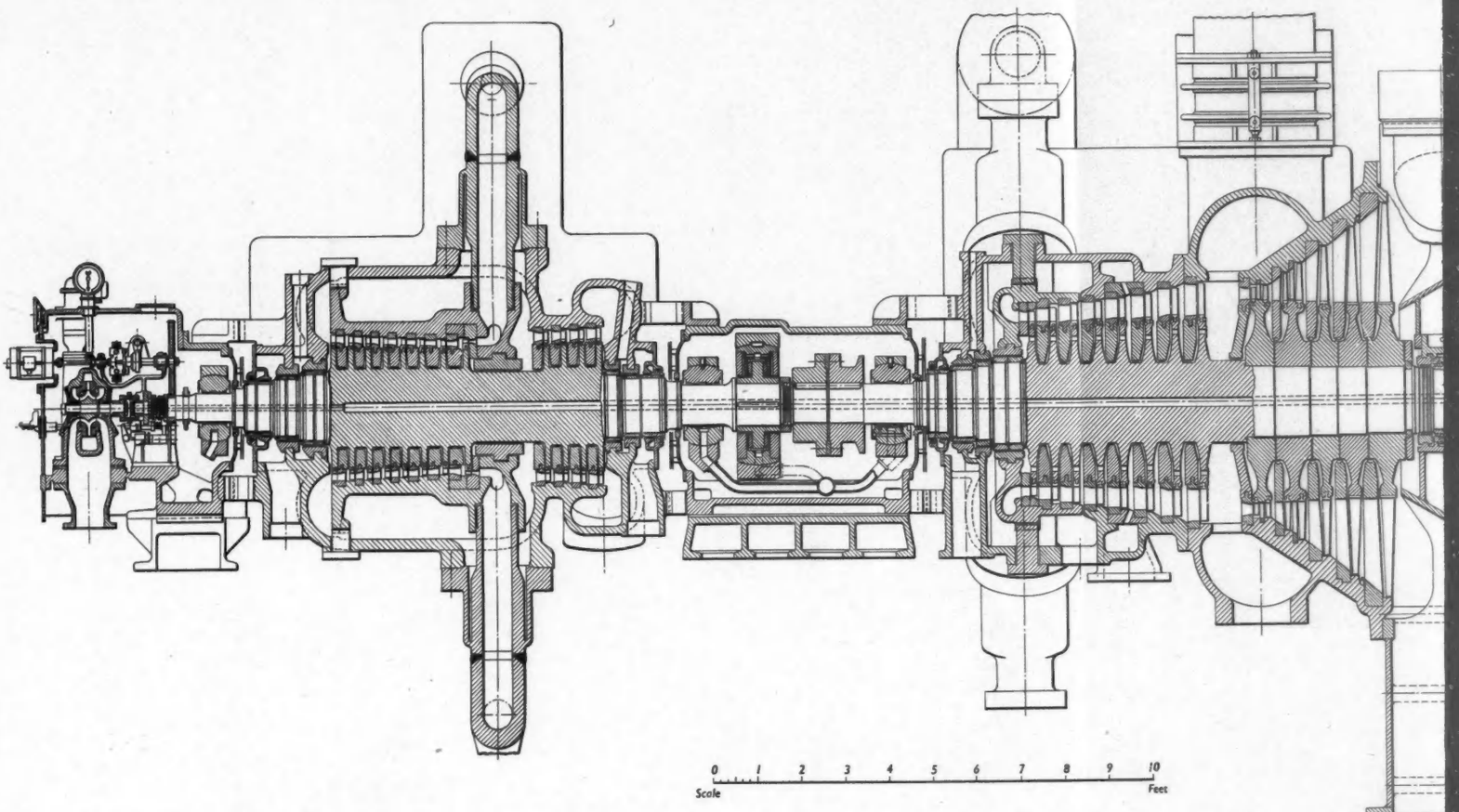
### On-Load Testing of Valves

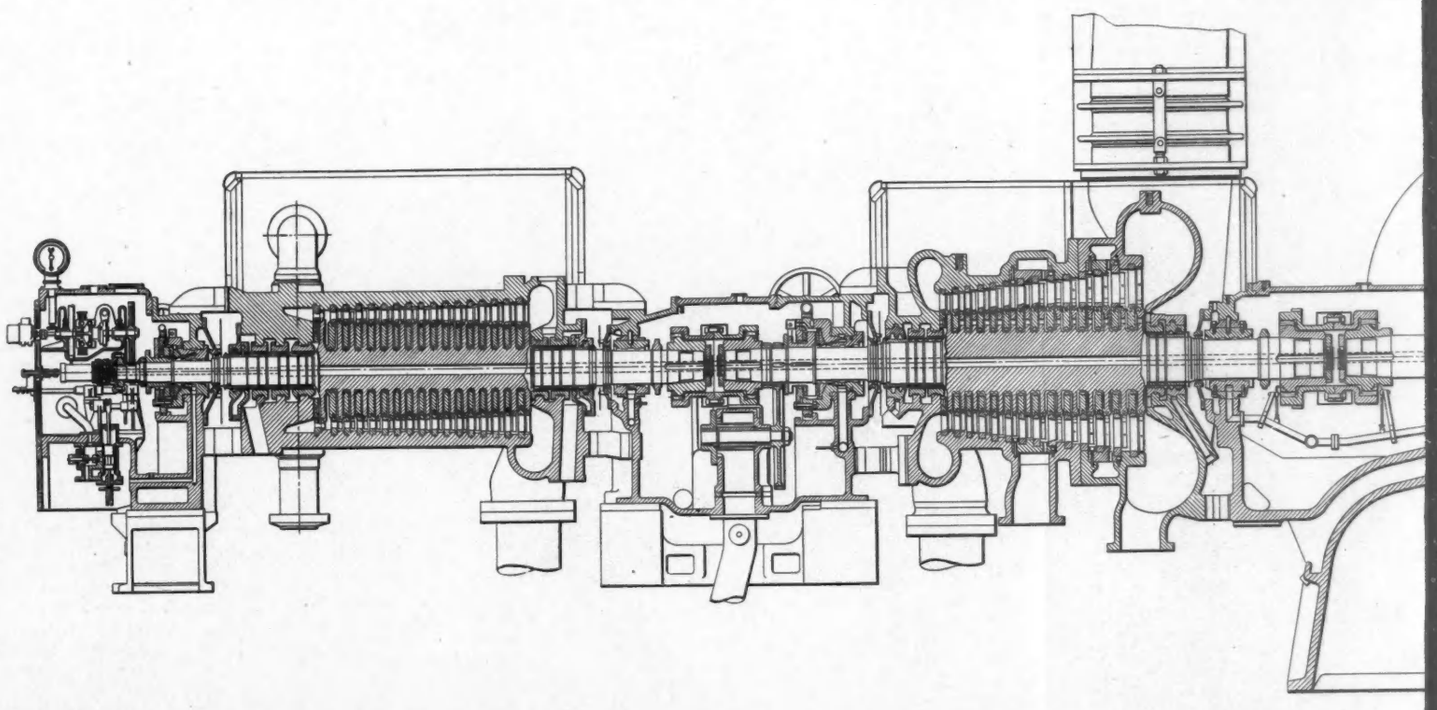
It has been shown above how great is the danger to a large set, if the rotors continue to develop steam torque after the load has vanished. Since we cannot do very much to reduce the danger by cutting down the volumes in which steam is stored, it has become vital that steam valves close promptly when called upon to do so. This applies to the governing valves and even more particularly to the interceptor valves and emergency stop valves. To ensure that they are free from sticking and are ready to operate at all times, frequent checking of each valve movement over its full stroke must be carried out. Arrangements can be made to enable each valve to be closed in turn, even with the set at or near full load initially, without causing a reduction of load of more than about 20 per cent. For this to be possible there must, of course, be more than one steam chest to maintain flow to the set when the valves in a given chest are closed. To avoid unbalancing the automatic control of the rate of fuel firing to the boiler during these valve tests, the flow of steam in both the main steam pipes should be maintained. This can be done by providing a cross connection between the two steam chests at a point before the stop valves.

A safety valve on the reheater piping is necessary, in case the interceptor valves between the reheater and the low-pressure part of the turbine should close for any reason, while one or more of the valves admitting high-pressure steam to the turbine remains in an open position.

§ "Developments in Steel Castings in the Heavy Power Plant Industry," F. Buckley, *Proc. I.Mech.E.*, 1953.

# SECTIONAL ARRANGEMENTS OF 200MW ANI



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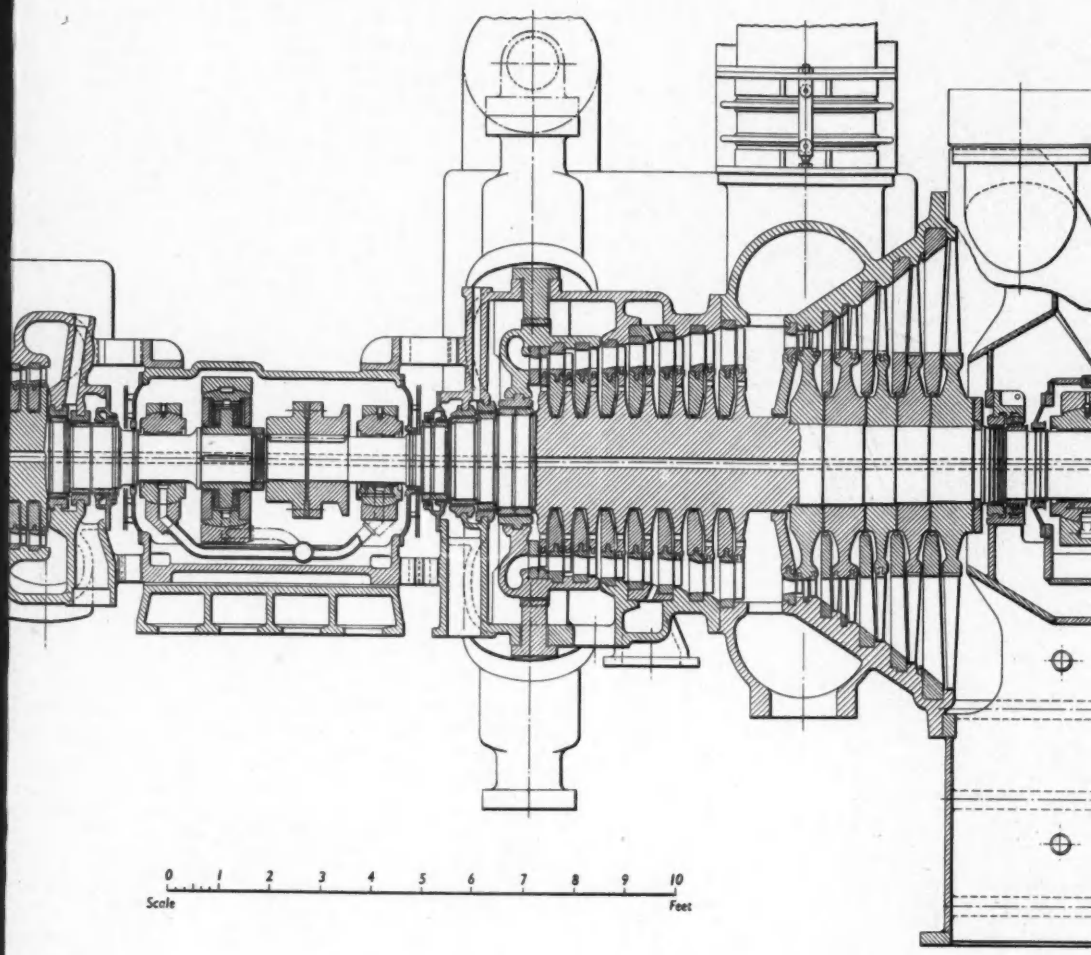


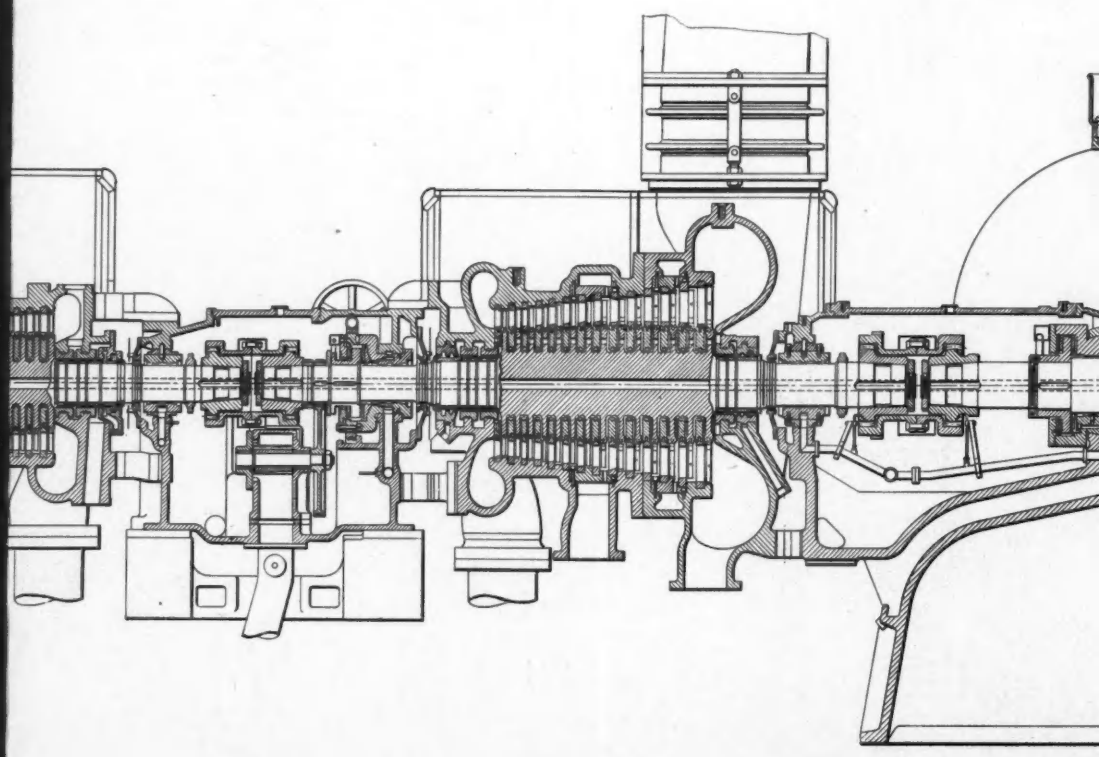

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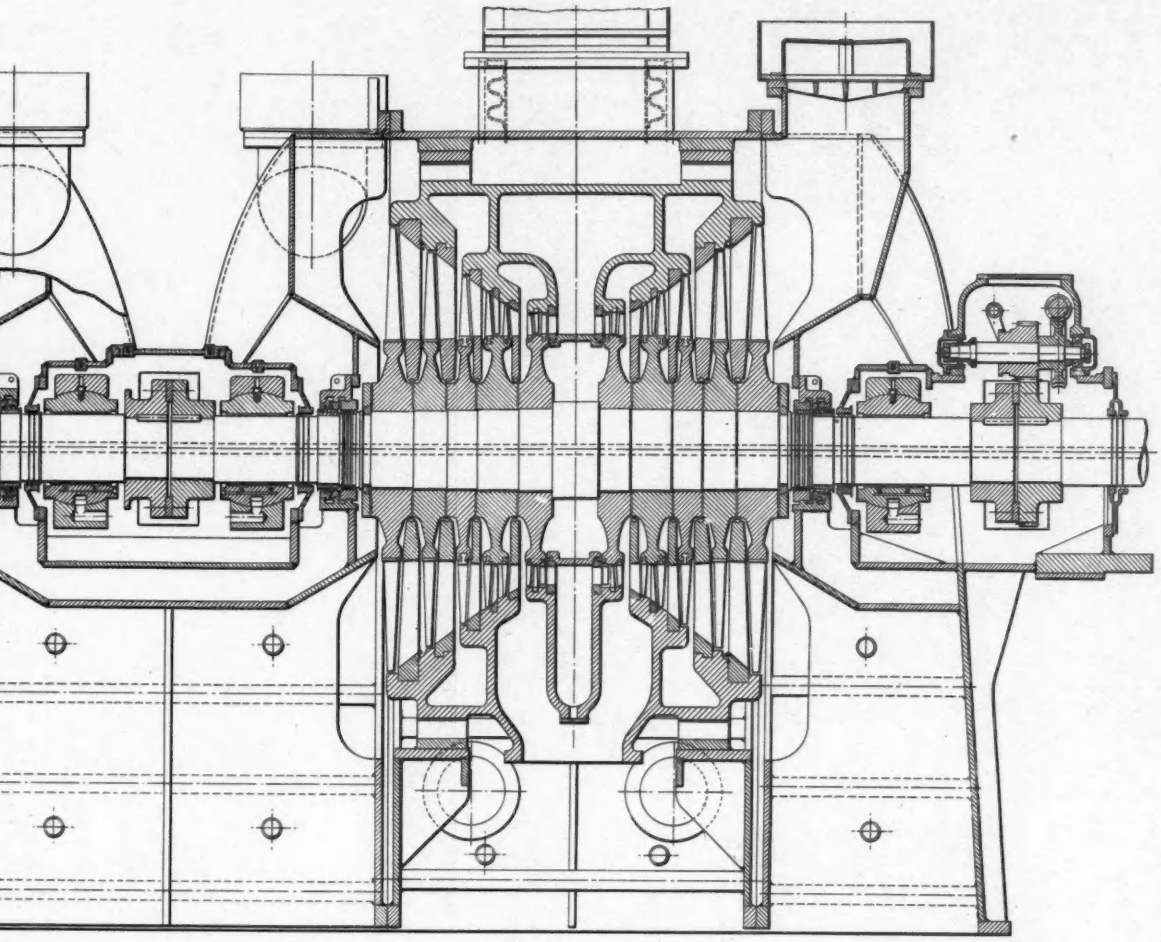
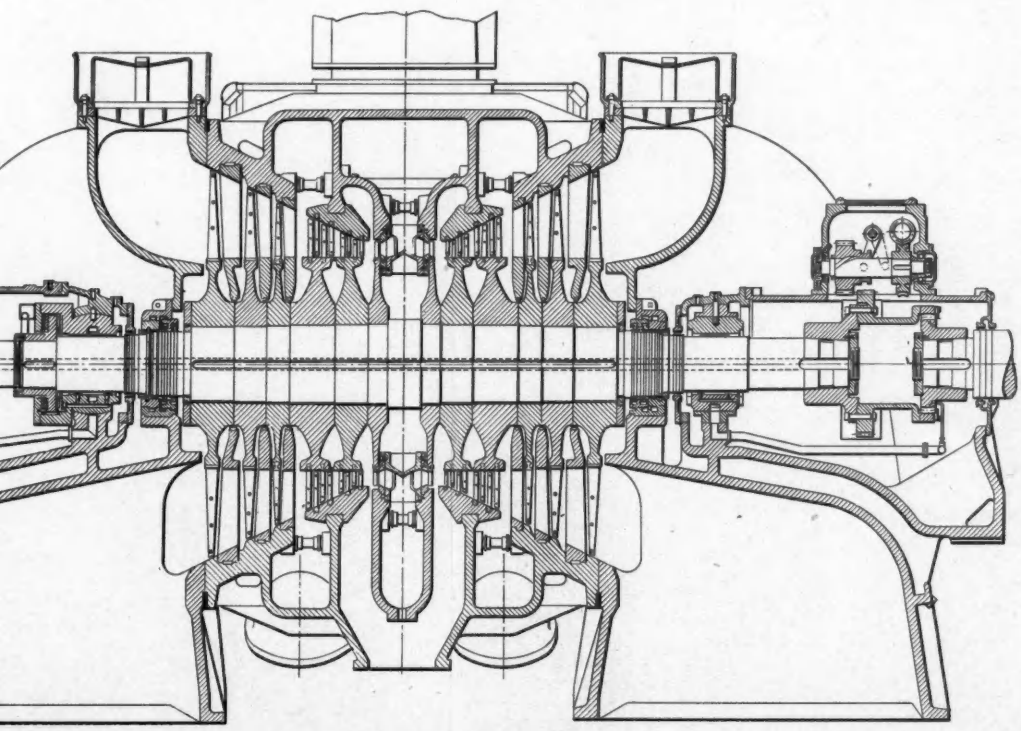




# Buckling under Complex Loading

By A. N. PROCTER, M.Sc.(Eng.), A.M.I.C.E., M.I.Struct.E.

No. II—( *Concluded from page 632, June 8th* )

*The purpose of this article is to show how strain energy methods of calculation may be used to investigate the elastic stability of structural members under the action of complex systems of loading, and to estimate the secondary bending produced by a combination of working forces and moments. Some experimental data are given to show the accuracy to be expected and to show the limits of slenderness within which the results would apply.*

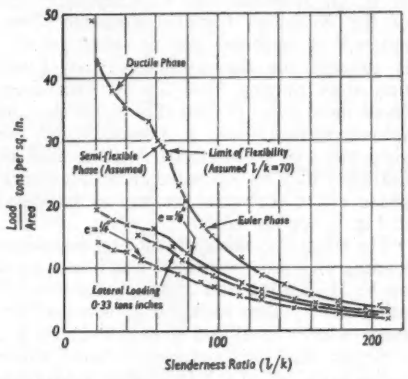
THE influence of eccentricity of loading and of lateral loading has been studied experimentally for steel struts.

Fig. 5 is based on Professor Lilly's tests[19] on nickel-steel ½in diameter solid round bars with ends freely hinged. In these tests the limit of flexibility appears to be at $l/k=70$, before the limit of proportion of the material is reached, and this also applies to the eccentrically loaded struts, but where the column is laterally loaded to a calculated stress of one-half of the ultimate strength the calculated maximum stress exceeds the yield stress of the material at $l/k=90$. Further reference is made to this series of tests in Table VIII. Tests on thinner alloy steel sections show that the Euler phase may extend to a considerably lower ratio of slenderness as shown in Fig. 7, the results of tests on heat-treated and normal chromium-molybdenum tubular steel struts by W. R. Osgood,[20] also eccentric loading based on tests made on solid round bars by Professor Robertson[7] and on tubes by W. R. Osgood.[20] The second phase of buckling of the bars occurs at a stress lower than the limit of proportion of the material, but the Euler phase of the tubes is limited by the ductility. The Euler limit of the bars is about $l/k=80$, which is in fair agreement with the value $l/k=83$ with ends round given in Johnson's *Materials of Construction*, 1939, page 19, $l/k=166$ being given for ends fixed.

Timber struts of reasonable flexibility usually have similar characteristics, but when large sections are tested, owing to the variability of their mechanical properties, the results are not very uniform. Fig. 8 shows the mean results of a series of tests in triplicate on yellow pine and on white pine columns made at Watertown Arsenal.[21] These columns were all of 5½in by 5½in square section and were tested with ends flat. The upper limit of the second phase coincides with the point where it is recorded that there was no deflection, so there the failure appears to have been by direct compression only. The two phases of elastic buckling are clearly marked, and these may also be seen in the tests on 2in by 1⅝in spruce struts tested by Professor Robertson[7] with ends free. It is not clear that the limit of proportion in compression is a limiting factor in the strength of timber struts, since the limit of proportion in bending, as calculated by the elastic theory of bending, is approximately equal to the crushing strength,[2] so that the third phase may have some relation to these two limits in relation also to the proportions of the test piece, this being a normal variation for all non-ductile compression test pieces of different height-thickness ratios.

In order to estimate the buckling conditions of a flexible member under complex loading from formulæ (4) or (4*a*) it is necessary to substitute an expression for $y_0$ in either formula and it has been found by trial that $y_0=\gamma . Z_y . \rho^2/A . \rho_0^2$ gives reasonably good results, where $A$ is section area, $Z_y$ the section modulus, $\rho$ is the slenderness ratio and $\rho_0$ is the limit of flexibility and $\gamma$ is a non-dimensional coefficient for the thickness, profile and material of the member. Using Professor Lilly's tests on nickel-steel struts referred to above (Table VIII) his results on the eccentrically loaded and laterally loaded struts have been compared with the relevant formulæ using $\rho_0=70$ and $\gamma=2\cdot1$. Between $l/k=230$ and $l/k=90$ the test values and the Euler formula are in reasonable agreement as also are the calculated and test figures for the complex loading, but at $l/k=80$ the test figures begin to fall below the Euler figures and this is considered in the first place to be due to the secondary effect of the small deflection referred to in formulæ (6) and (6*a*), so that by transposing formula (6*a*) and substituting for $y_0$ as above it is possible to estimate this assumed effect at or near the limit of flexibility, and these results are shown in brackets over the Euler figures. In the second phase the value of $p_y'=P_Y'/A$ is estimated from

$$\frac{\pi^2 . E . A}{\rho_0^2 . A}\times\frac{\rho_0}{\rho}=\frac{\pi^2 . E}{\rho_0 . \rho}.$$




Properties of material : ultimate strength, 53·7 tons per square inch ; limit of proportion, 35·7 tons per square inch ; Young's modulus, 13,800 tons per square inch.

**Fig. 5—Buckling of ½in diameter solid round nickel steel bars, ends free, under axial, eccentric and combined axial and lateral loads**

TABLE VIII—*Tests on the Buckling of Eccentrically and Laterally Loaded Solid Round Struts, by Professor Lilly*[19]

Bars were ½in diameter ; $E$=13,800 tons per square inch ; Ult. Strength 53·7 tons per square inch ; Yield Point of material 35·7 tons per square inch. All bars tested with ends freely hinged. Lateral loads applied at mid-length.

| Slenderness ratio ($\rho$) $l/k$ | Buckling load/area Tons per square inch | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Axial loading | | Eccentricity ½in | | Eccentricity ½in | | Laterally loaded $M_{Yy}$=0·33in-ton | |
| | Test | Calc. ($p_y$) | Test | Calc. ($f_a$) | Test | Calc. ($f_a$) | Test | Calc. ($f_a$) |
| 230 | 2·57 | 2·6 | 2·25 | 2·34 | 2·2 | 2·15 | 1·9 | 1·65 |
| 212 | 3·01 | 3·03 | 2·7 | 2·7 | 2·45 | 2·4 | 2·15 | 1·95 |
| 196 | 3·44 | 3·55 | 3·1 | 3·1 | 2·8 | 2·7 | 2·4 | 2·15 |
| 180 | 4·03 | 4·23 | 3·6 | 3·6 | 3·1 | 3·1 | 2·55 | 2·6 |
| 164 | 5·07 | 5·07 | 4·0 | 4·15 | 3·35 | 3·5 | 3·2 | 3·1 |
| 148 | 6·35 | 6·22 | 4·9 | 4·9 | 3·8 | 4·0 | 4·0 | 3·8 |
| 130 | 8·16 | 8·05 | 6·25 | 6·0 | 4·9 | 4·75 | 5·4 | 5·1 |
| 114 | 11·2 | 10·5 | 7·4 | 7·2 | 5·8 | 5·5 | 7·3 | 7·3 |
| 99 | 13·6 | 13·9 | 8·5 | 8·65 | 6·7 | 6·3 | 8·5 | 8·4 |
| 90 | 17·2 | 17·15 (20·6) | 10·5 | 9·8 | 7·6 | 7·0 | 10·3† | 10·9 |
| 80 | 20·5 | 21·25 (25·4) | 11·2 | 10·9 | 8·3 | 7·4 | 12·5† | 13·2 |
| 72 | 25·0 | 26·3 | 12·0 | 12·0 | 8·9 | 8·4 | 13·8† | 16·4 |
| Semi-flexible phase. | Limit of flexibility ($\rho_0$). | | | | $l/k$=70, found by inspection. | | | |
| 60 | 31·7 | ($p_y'$) (31·5) 33·7 | 13·4 | ($f_a'$) 14·4 | 10·25 | ($f_a'$) 9·4 | 16·2† | ($f_a'$) 22·0 |
| Ductile phase | | | | | | | | |
| 50 | 33·0 | | 15·2 | | 11·15 | | | |
| 42 | 33·5 | | 16·5 | | 12·5 | | | |
| 32 | 37·9 | | 17·9 | | 12·7 | | | |
| 22 { | 42·5 | | 19·6 | | 14·05 | | | |
| | 49·0 | | | | | | | |

$p_y$ is calculated from Euler formula.

$$f_e=\frac{p_y}{1+\frac{1\cdot27e\,.\,A}{2\cdot1Z_y}\left(\frac{\rho_0}{\rho}\right)^2} \qquad f_a=p_y-\frac{0\cdot82M_{Yy}\left(\frac{\rho_0}{\rho}\right)^2}{2\cdot1Z_y}$$

$$p_y'=\frac{\pi^2\,.\,E}{\rho_0\,.\,\rho} \qquad f_e'=\frac{p_y'}{1-\frac{1\cdot27e\,.\,A}{2\cdot1Z_y}} \quad \text{and} \quad f_a'=p_y'-\frac{0\cdot82M_{Yy}}{2\cdot1Z_y}.$$

† In these tests the calculated yield stress of material was exceeded.

tests by Professor Robertson[7] on nickel-chromium steel tubes of lower yield strengths. The apparent limit of flexibility of the heat-treated tubes appears to be at $l/k=49$, considerably less than the solid nickel steel bars referred to above. When eccentrically loaded the softer steel tubes showed two phases beyond the Euler phase and also when axially loaded, the second phase point being in all cases at about $l/k=49$. The thickness of metal was here 0·035in and 0·048in.

The different behaviour of "Duralumin" bars and tubes when tested as struts with ends freely hinged is illustrated in Fig. 9, which is

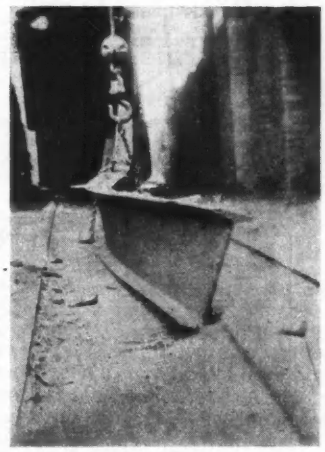


Fig. 6

The laterally loaded struts failed by yielding of the material before the second phase was reached, but the method of calculation gives reasonably accurate results for the other tests, the coefficient $\beta=0\cdot82$ being taken from Table I and ref.[22] for mid-span loading.

The same method of calculation may be used to estimate the buckling loads of eccentrically loaded R.S. I section columns in the elastic phase. Using the results of tests by M. Ros and J. Brunner,[23] of B. G. Johnston and L. Cheyney,[24] and of the American Column Research Committee,[25] it is found that a value 1·4–1·5 is suitable for the coefficient $\gamma$ of I section sizes ranging from 3in to 12in deep. In all these series of tests it is found that the second elastic phase is prevented by the yield point of the material, but the limit of flexibility may be estimated from the ductile phase under eccentric loading, as indicated in Fig. 7, for the tubes.

The effect of combined axial and transverse loading on timber members was investigated by V. H. Barling and J. D. H. Pritchard,[26] using 2in by 1½in spruce test pieces 4ft 6in long. Under axial and transverse loading it is found that the coefficient $\gamma$ used above varies from 3·8 to 4·8 for timber sawn from different parts of a log ($\rho_0$ assumed to be $l/k=70$ from Fig. 8). These results were obtained when the duration of loading was from five to six minutes, but when the loading was applied for a period of ten hours the carrying capacity of the timber decreased under combined loading about 33 per cent, compared with 10 per cent under transverse loading only, so that it would evidently be unsafe to use data on the properties of timber found by short-time tests to estimate the effect of combined loading of practical duration.

Similarly, the time of loading is a material factor to consider when the sum of all stresses exceeds the creep limit. These in the example shown in Fig. 1 *ante* would be $f_a+f_x+f_y$ plus the secondary bending stress caused by the deflection $y_0\pm\frac{1}{2}d\,.\,\theta_0$, which would be $6(f_a+f_x)(y_0\pm\frac{1}{2}d\,.\,\theta_0)/\psi b$, where $b$ is the breadth of the member. The shape factor ($\psi$) of the deflection in the direction of buckling is mainly dependent on the value and direction of the active or restraining end couples ($M_{Fy}$) and the stiffness of the member. For an axially loaded strut with fixed ends, using the simple formula (from formula (2*a*), $F_A''=4P_F-2M_{Fy}/\pi y_0$ the fixing moment which restrains the ends of the member is the whole or part of the bending moment $M_{Fy}$, which is equal to $\pi y_0/2\,.\,(4P_F-F_A)$, so that when $F_A=4P_F$ the fixing moment required is zero, but for all other values of $F_A$ a fixing moment is required, otherwise the shape of the deflection curve ($\psi$) will change, or alternatively $y_0$ must be zero. The test results in Table IX are taken from Professor Hodgkinson's tests on small cast iron struts.[17]

It will be seen from these figures and also from buckling tests on 3in×1·33in×5·7lb per foot American I section R.S. columns by B. Johnston and L. Cheyney shown in Fig. 10, Table IV, and other tests,[15] that a long column of normal or thick section with ends fixed or flat usually fails at about $F_A''=3P_F$, and it follows from this that the maximum value of $M_{Fy}$ at that point would be $\pi y_0/2\,.\,P_F$. Assuming sinusoidal deflection, it is clear from Fig. 2 that the end fixing moment is $\frac{1}{2}y_0\,.\,F_A$, and equating these two

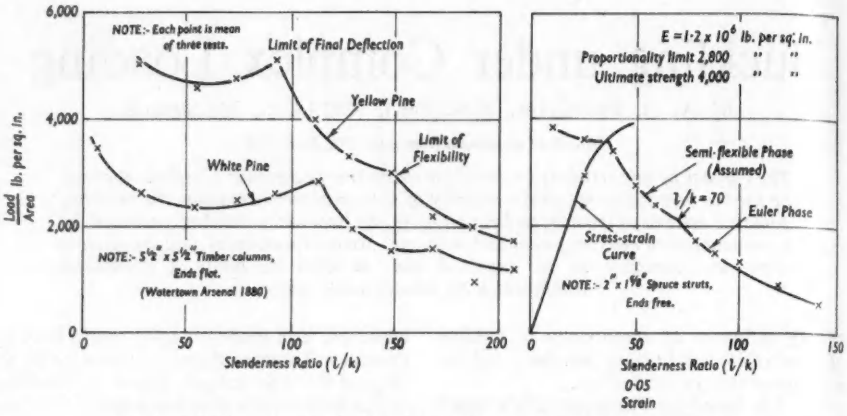
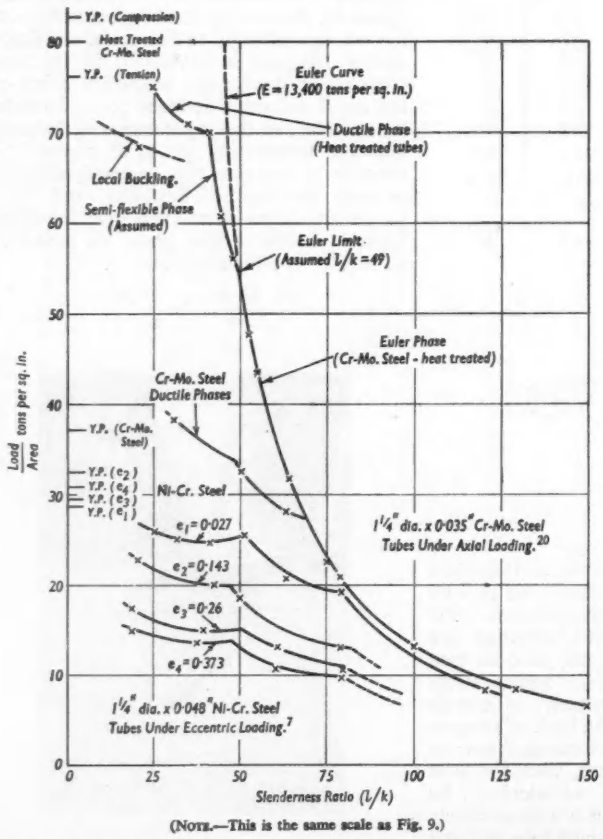
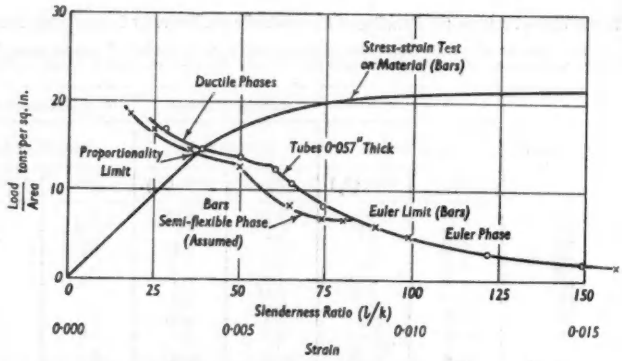

NOTE:- Each point is mean of three tests.
Limit of Final Deflection
Yellow Pine
Limit of Flexibility
White Pine
NOTE:- 5½" x 5½" Timber columns, Ends flat. (Watertown Arsenal 1880)
Load / Area lb. per sq. in.
Slenderness Ratio (l/k)
E = 1·2 x 10⁶ lb. per sq. in.
Proportionality limit 2,800 " "
Ultimate strength 4,000 " "
Semi-flexible Phase (Assumed)
l/k = 70
Euler Phase
Stress-strain Curve
NOTE:- 2" x 1⅛" Spruce struts, Ends free.
Slenderness Ratio (l/k)
0·05
Strain

**Fig. 8—Buckling of axially loaded timber columns with ends flat and ends free**


Y.P. (Compression)
Heat Treated Cr-Mo. Steel
Y.P. (Tension)
Euler Curve (E = 13,400 tons per sq. in.)
Ductile Phase (Heat treated tubes)
Local Buckling.
Semi-flexible Phase (Assumed)
Euler Limit (Assumed l/k = 49)
Euler Phase (Cr-Mo. Steel - heat treated)
Cr-Mo. Steel Ductile Phases
Y.P. (Cr-Mo. Steel)
Y.P. (e2)
Y.P. (e4)
Y.P. (e3)
Y.P. (e1)
Ni-Cr. Steel
e1 = 0·027
e2 = 0·143
e3 = 0·26
e4 = 0·373
1¼" dia. x 0·035" Cr-Mo. Steel Tubes Under Axial Loading.[20]
1¼" dia. x 0·048" Ni-Cr. Steel Tubes Under Eccentric Loading.[7]
Load / Area tons per sq. in.
Slenderness Ratio (l/k)

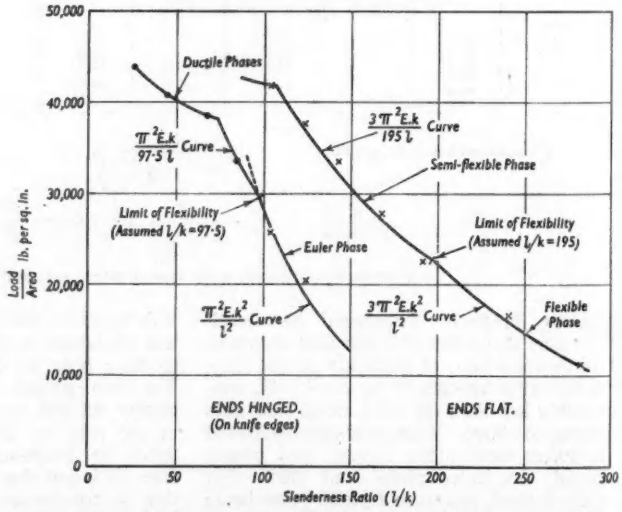
(NOTE.—This is the same scale as Fig. 9.)

**Fig. 7—Buckling of alloy steel tubes (ends free) under axial and eccentric loading**




$E$=4750 tons per square inch. Proportion limit, 14·5 tons per square inch (bars).
$E$=4750 tons per square inch. Proportion limit compression, 14·5 tons per square inch (bars); 13·5 tons per square inch (tubes).

**Fig. 9—Buckling of axially loaded solid round duralumin bars and 1⅛in diameter by 0·057in thick tubes**


Ductile Phases
π²E.k / 97·5 l Curve
3π²E.k / 195 l Curve
Semi-flexible Phase
Limit of Flexibility (Assumed l/k = 97·5)
Euler Phase
Limit of Flexibility (Assumed l/k = 195)
π²E.k² / l² Curve
3π²E.k² / l² Curve
Flexible Phase
ENDS HINGED. (On knife edges)
ENDS FLAT.
Load / Area lb. per sq. in.
Slenderness Ratio (l/k)

$E_{(compression)}=30\times10^6$ lb per square inch. $E_{(tension)}=29\times10^6$ lb per square inch. Average Y.P.=40,800 lb per square inch. Average Y.P. (material lot 2)=40,800 lb per square inch. NOTE.—Other material used for four tests marked "•." Curves are based on $E_{(tension)}$.

**Fig. 10—Buckling tests on axially loaded 3in by 1·33in by 5·7 lb/foot American I-section M.S. columns with ends hinged and ends flat**

TABLE IX

| Length, inches ... ... ... ... ... ... ... Diameter, inches ... ... ... ... ... ... | 60·5 0·5 | 30·25 0·78 | 30·25 1·0 | 30·25 1·02 | 60·5 1·76 | Approximate ratio |
|---|---|---|---|---|---|---|
| Both ends round (pounds) ... ... ... ... ... | 143 | 3,017 | 7,009 | 7,009 | 16,493 | 1 |
| One round, one flat ... ... ... ... ... ... | 256 | 6,278 | 13,499 | 13,499 | 33,557 | 2 |
| Both ends flat ... ... ... ... ... ... ... | 487 | 9,007 | 20,310 | 22,475 | — | 3 |
| Ends flat/Ends round ... ... ... ... ... | 3·4 | 2·94 | 2·9 | 3·17 | — | — |

values $F_A'' = \pi P_Y$, which agrees fairly well with Hodgkinson's experiments. Substituting for $y_0$, $M_{Yy}$ would equal

$$\frac{\pi}{2} \cdot \gamma \cdot \frac{Z_y}{A} \cdot \frac{\rho^2}{\rho_0^2} \cdot P_Y$$

and when $\rho = \rho_0$ (for R.S.J.s with ends fixed about $l/k = 200$) the bending stress due to the fixing moment would be $f_y = \pi \cdot \gamma \cdot p_y/2$ or $\pi \cdot \gamma \cdot f_a/6$. Using $\gamma = 1{\cdot}5$ this would be about $0{\cdot}8 f_a$, so the maximum stress at the ends and mid-length is about $1{\cdot}8 f_a$, or about 18 tons per square inch. It appears from this that it is not possible to restrain the ends of an R.S.J. of $l/k < 200$ to develop the full buckling strength of $4P_Y$ because the maximum combined stress would usually exceed the yield strength of the material, but this may not apply to thin section struts. When very thin sections are used it is possible to develop the full buckling strength, $4P_Y$, with ends flat,[27] provided the slenderness ratio is sufficiently high, and under these conditions the end fixing moments at the point of buckling would be very small.

In a letter to Thomas Young, who first published the formula for the deflection of a bent strut, used later by Professor Perry,[28] George Rennie Junior observed[29]: "It is only by devising theory from carefully directed experiments that practical results can be obtained." A careful study of the large amount of reliable test data which is now available will eventually, in the writer's opinion, give the correct solution to all these problems and pave the way to more accurate methods of design.

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# Uniformly Distributed Loading for Laboratory Tests

By J. S. CASWELL*

*The provision of uniformly distributed loading of high rating is sometimes necessary for tests on beams and slabs, and also for the edge loading of panel plates. This kind of loading is not readily obtained with the usual facilities available in a materials testing laboratory, and consideration is given to a common but unsatisfactory method of loading. Approximate and improved methods of obtaining good approach to uniformly distributed loading are described and reference is made to a hydraulic uniform loader which was developed for this special purpose.*

UNIFORMLY distributed loading of fairly large rating is sometimes required for test purposes in a materials testing laboratory. It is not always convenient to use fluid pressure loading directly, and a common method of obtaining apparent uniformity of distributed loading for direct compression is shown in Fig. 1 (*a*), in which a concentrated load $W$ is applied to a steel bar $A$ and an interlayer of soft material $B$ to a structural part $C$ under test. The load distribution along the surface $DE$ is not uniform, but for some purposes, e.g. the examination of effects remote from the point of loading, this method may be satisfactory. Coker and Filon† have shown that for the idealised case of such loading, transmitted through a steel bar to a rigid plane surface, the general form of the load intensity curve is as shown in Fig. 1 (*b*). The maximum intensity occurs directly under the load $W$ and the value decreases on each side of the point of application of the load, falling to zero at a distance of $1{\cdot}35d$ on each side, where $d$ is the depth of the bar of uniform width $b$. Consequently, this method is not satisfactory when uniformity of loading is required.

In order to obtain a good approach to uniform distribution of the load $W$, it is necessary to subdivide the load into a number of equal smaller loads and to space these at equal distances along the upper face of the bar, as in Fig. 2 (*a*). The approach to uniformity could be still further improved by producing some load dispersion at each point of load application, and the depth $d$ of the bar could then be reduced.

This break-up of a single load $W$ into a number of equal and equally spaced loads may be carried out by using a single-sided hydraulic loader, as shown at *SSL*, in Fig. 2 (*b*), in which loose pistons are fitted into interconnected cylinders. The external ends of the pistons are enlarged to provide a square section loading face, which may be made flat or slightly convex as may be determined by the testing requirements. For the assumed perfect conditions of surface contact along $DE$, the intensity of loading would then be nearly uniform over the whole length and, for the same load $W$, it would be equal to the average value shown in Fig. 1 (*b*).

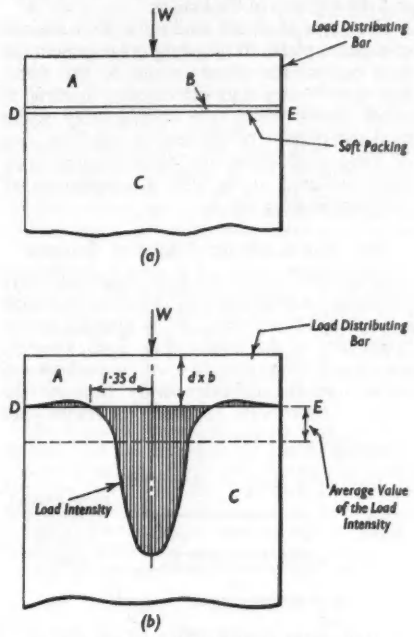



**Fig. 1—Variation of load intensity with a single concentrated load**

For many purposes, satisfactory approach to uniformly distributed loading could be obtained without the use of the steel bar $A$; i.e. by using only a thick pad of tough material between the hydraulic loader and the surface of the test piece, as shown in Fig. 3 (*a*), which shows a slab loaded by a multi-piston, laterally-extended, single-sided loader.

The disadvantage of the load system shown in Fig. 2 (*b*) is that high stresses are produced

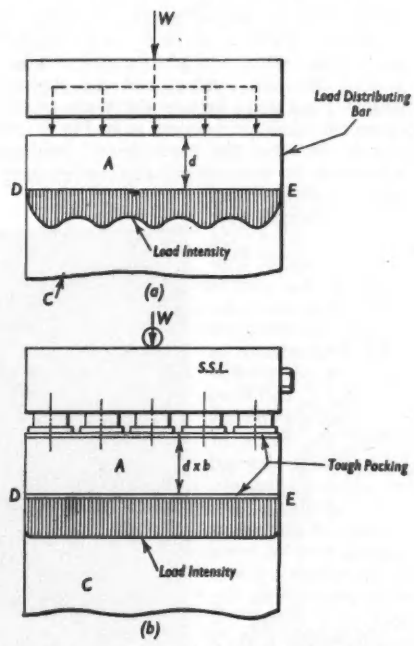



**Fig. 2—Approach to uniformly distributed loading**

in the cylinder block of the loader by the combined effect of the local application of the load $W$ and the creation of large bending moments, and these stresses are superimposed on the separate stress system produced by the fluid pressure in the cylinder body. The superimposed stresses may be reduced to smaller values by distributing the applied

* Senior Lecturer in Mechanical Engineering, University College of Swansea.

† *Photo-elasticity*. Cambridge University Press, 1931, page 436.

load over a part or all of the upper face of the loader, as shown in Fig. 3 (*a*), but it is necessary to ensure good surface contact between the compression machine platen and the top face of the loader.

For cases of direct loading, e.g. in the test of a panel plate, the loading arrangements at each end of the panel should be the same. For long beams and direct edge loading of panel plates which are considerably wider than the platens of the testing machine, one or more single-sided hydraulic loading units could be used along with a supplementary load distributing beam.

### The Double-Sided Uniform Loader

Although the arrangements described above represent an improvement over that in which a single concentrated load is applied to the upper face of the loader, Fig. 2 (*b*), they do not avoid the creation of superimposed stresses in the cylinder body because the contact conditions between surfaces are

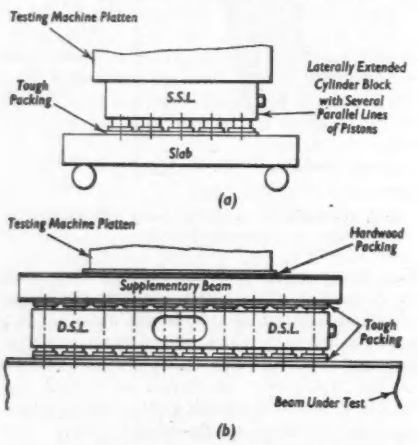



**Fig. 3—Single-sided and double-sided hydraulic uniform loaders**

imperfect, and unequal elastic straining of the machine platen and the hydraulic loader occurs under load ; and particularly so when parts of the unit loaders and the supplementary bar extend beyond the edges of the compression machine platen, as in Fig. 3 (*b*). In order to meet the experimental loading requirement in a more satisfactory manner, contact stresses and bending moments were eliminated from the cylinder block by converting the single-sided hydraulic loader into the double-sided form‡ *DSL*, shown in Fig. 3 (*b*). The interconnected cylinders were bored completely through the block of steel and loose opposed pistons were fitted into each cylinder. The cylinder block was completely filled with oil and provision was made for sealing the block after filling, or for connecting it to a high pressure oil pump. A cylinder block unit comprises five or ten cylinders, and oil pressure connections are provided when several blocks are required for extended uniformly distributed loading. An example of a loading condition, for which this kind of loader is required, is shown in Fig. 4 (*a*), when it is necessary to produce simultaneous loading of small scale top and bottom rolls, such as occurs in the rolling of steel and non-ferrous strip.

‡ Patent Specification 722,528.

### A Test of the Loader

This type of loader was developed primarily for the purpose of obtaining a close approach to uniformly distributed loading during tests on beams of conventional cross-section and small rolls of low span-depth ratio. A 10in double-sided loader (Fig. 5) was made of high-

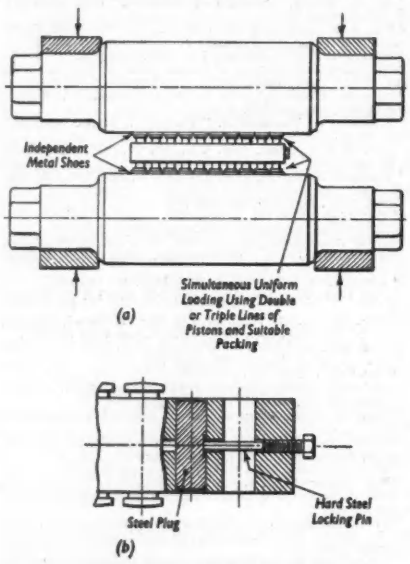
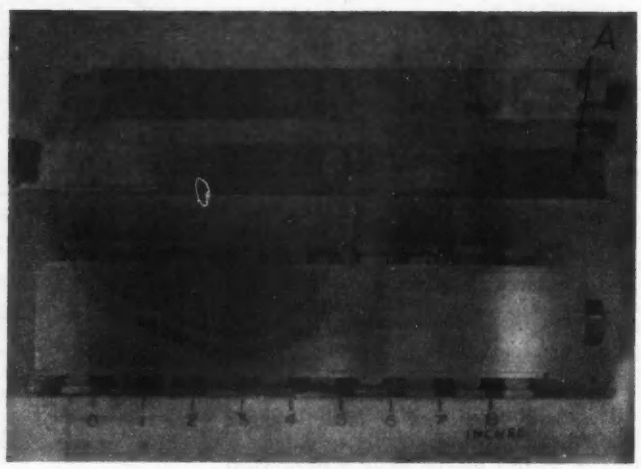

Independent Metal Shoes
(a)
Simultaneous Uniform Loading Using Double or Triple Lines of Pistons and Suitable Packing
Steel Plug
Hard Steel Locking Pin
(b)

**Fig. 4—(a) Hydraulic uniform loading for tests on small experimental rolls: (b) Method of sealing the cylinder block after removing some of the pistons**

tensile Ni-Cr steel, and this was tested up to a total safe load of 45 tons, i.e. 4·5 tons per inch. This load produced an oil pressure of 24,550 lb per square inch in the cylinder block. The load was steadily maintained for five minutes and no leakage of oil was observed. The full capacity of the loader is probably much higher, but larger loads were not applied because it was necessary to avoid risk of damage to the loader.

During this test aluminium alloy strips were placed between the pistons and the platens of the testing machine; and the indents, made simultaneously on these strips, may be observed in the photograph, Fig. 5.



*A.* "Duralumin" strips showing piston indents under total load of 45 tons.

**Fig. 5—A 10in double-sided hydraulic uniform loader, capacity 5 tons per inch**

For work in progress it was necessary to change the limits of uniformly distributed loading to lengths of 10in, 8in, 6in and 4in, and this was simply achieved by removing the necessary number of pistons and then fitting a snugly fitting plug into the appropriate empty cylinder and sealing the interconnecting channel by metal-to-metal contact under pressure, in the manner shown in Fig. 4(*b*). Numerous variations are possible in the form and use of either the single or double-sided type of loader.

With a triple line loader made of suitable high-tensile steel, uniformly distributed loads up to 30 tons per inch within a loader width of 3½in and with any desired length are practicable. When a compression testing machine is not available a calibrated hydraulic loader can be coupled to a high-pressure oil pump and the applied loads can be directly observed on a suitably graduated pressure gauge. For some purposes the single-sided loader is satisfactory, but for special purposes and heavy loading the double-sided loader is preferable.

The work here described has been carried out with the help of the National Research and Development Corporation and with the aid of part of a grant received for other purposes from the Department of Scientific and Industrial Research.

## Industry and Technical Education

General agreement with the Government's plans for technical education has been expressed in a memorandum which the Federation of British Industries has sent to the Minister of Education. In some comments on the subject the Federation expresses the view that the progress of technical education in this country is dependent on a development of the technical colleges on lines indicated in the recent White Paper, on an expansion of university facilities, and on a strengthening of science teaching in secondary schools. But it is pointed out that no attempt has been made in the White Paper to state in what period of time the proposed increases in the numbers of technicians and technologists should become effective, nor is there any indication of any steps contemplated by the Government to enlist co-operation required from the public, from parents, from teachers and from industry. The Federation fears that in the absence of more specific plans the outcome may be disappointing. Similarly, though the Federation supports the Government's proposal to provide for a big increase in the number of young workers released by employers for daytime studies, it has noted that again the White Paper sets no time limit for the proposed doubling of the number of day-release students. A rapid advance to the suggested target would call for maximum support from industry. The Federation regards the day-release system as a valuable method of providing further training for potential technicians and technologists.

The Federation considers that the Government's capital investment plans, important as they are, should be accompanied by parallel plans in the recruitment and training of teachers in the technological field ; for, it says, the quality of the teaching is no less important than the number of teachers recruited. But the three technical teacher training establishments, which have been brought into existence since the war, are of limited influence and usefulness owing to the financial sacrifices involved for most of the student teachers, and their consequent reluctance to enter for these courses.

# High-Voltage Power Systems

## C.I.G.R.E. MEETING IN PARIS

### No. I

*The sixteenth meeting of C.I.G.R.E., the international conference on large high-voltage power systems, was held at the Fondation Berthelot, 28, Rue St. Dominique, Paris, from May 30 to June 9, 1956, and was attended by delegates from forty-three countries. At the opening ceremony the French Minister of Industry presided and the delegates were welcomed by Dr. R. A. Schmidt, president of C.I.G.R.E., who gave a review of the activities of the Conference. The technical sessions began on May 31st. Groups of papers were discussed dealing with alternators, transformers, circuit breakers, high-voltage cables, overhead lines and towers, insulators, protection and relaying, system stability and load and frequency control, and transmission by d.c. and a.c. at extra high voltages. A short résumé of the discussions is given here.*

TWO topics, transformers and overhead lines, were discussed on Thursday, May 31st, which was the first technical session of the conference.

#### Transformers

In his introductory remarks as chairman of the transformer session, Mr. E. T. Norris suggested that the discussion should be concerned with four main matters, namely: impulse testing with special emphasis on fault location; the reduction of transformer noise; the problems of short circuits on large transformers; and on-load tap changing.

*Impulse Testing.*—Five papers formed the basis of the first of these topics. Three of these papers were concerned with chopped-wave impulse testing of transformers. Mr. L. L. Preston's paper, "Chopped-Wave Impulse Testing of Transformers," described a method of producing an accurate chopping time and gave the results of applying this method to the chopped-wave testing of a small transformer with artificially applied faults. The characteristics of rod gaps were briefly reviewed and the requirements for fault detection were determined in the paper.

In his contribution to the discussion Mr. Meador (U.S.A.) said that it was clearly impracticable for a transformer manufacturer to have two ranges of transformers, one designed for normal full-wave testing and the second for chopped-wave testing. Approximately 85 per cent of all the transformers in the U.S.A. were, he estimated, protected by lightning arresters. Naturally-induced chopped waves were comparatively rare in service, but they could, of course, occur in exceptional conditions, for example, during the flashover of a bushing. However, the effect of switching surges was not known with any accuracy and that provided justification for the policy of designing transformers to comply with a chopped-wave test. Dealing with the fault-detection aspect, he said that, in his experience, if a fault had arisen under chopped-wave testing it could be detected on a full-wave test, assuming that the intervening time between the two tests was short.

Mr. G. Jancke (Sweden) referred to some interesting work done on switching surges by the Swedish State Power Board, from which it could be concluded that the chopped-wave test should not be regarded as providing a substitute for the actual stresses resulting from switching.

A similar conclusion was reached by Mr. G. B. Harper (Great Britain), who thought that the form of testing under discussion did not simulate operating conditions. Some form of compromise was required, for, whilst chopped-wave testing might be too severe for transformers equipped with surge diverters, it was essential with rod gaps. He agreed with Mr. K. E. Stenkvist's suggestion that the time-to-chopping constant should be about 3 microseconds.

Mr. M. Pierson (Belgium) discussed some of the difficulties of fault location by the examination of oscillograms. Over a three-year period of testing work he had had both successes and failures. As a result his belief was that it was impossible to get consistent results with an impulse generator and he showed a number of oscillograms to prove how easily spurious results could be obtained. However he agreed that with the use of Mr. Preston's equipment, consistent results should be obtainable.

Mr. F. S. Edwards (Great Britain) said that the time interval of 3 microseconds was not universally acceptable. An objection to the proposed use of a slow front wave was that it did not represent service conditions. He preferred a chopped standard wave.

A testing method with precise control of the chopping time was favoured by Mr. J. E. L. Robinson (Great Britain) who said that between 3 and 9 microseconds there would be a point giving maximum test severity. However, he did not think that the added severity at that point was serious.

*Transformer Noise.*—The subject of transformer noise came under discussion in the afternoon. Mr. Baron (France) commented on the possibilities of a specification for medium noise level. He had found that it was possible to have variations in noise level of up to 10dB between similar transformers. It should also be possible and it would certainly be desirable to collect data on tolerance to noise which varied widely not only between individuals, but also between different sections of a community such as urban and country dwellers.

Referring to a description given in one of the papers of a sound-proof enclosure, Mr. R. S. Orchard (Great Britain) said that the consequential rise in the maximum temperature of the enclosed transformer was likely to cause a reduction in rating. On the other hand, a marked improvement could be effected by better construction, and he described how, many years ago, the noise level in a small transformer had been reduced by 30dB by closer attention to clamping and other details.

Mr. C. L. Walters (Great Britain) outlined some of the difficulties of preserving amenities when erecting and operating large 132kV transformers of the order of 60MVA rating in populous urban areas. He said that some of the noise nuisance could be avoided by installing the tank in a sound-proof enclosure, leaving the radiators outside—a form of construction that did not seriously affect the winding temperature rise. He gave a detailed description of a specific example of this method of soundproofing.

*Transformer Short Circuits.*—Mr. E. Stenkvist and Mr. L. Torseke (Sweden) commented on existing standards in their paper on the ability of large power transformers to withstand short circuits. They found that there was insufficient published information about the methods of calculation whereby the mechanical short-circuit forces in large transformers could be accurately assessed. Similarly, little information was published on the physical properties of copper under the severe mechanical forces that could be associated with the incidence of short circuits. In these circumstances, full-scale tests were necessary if one wanted to find out the effect of a short circuit. Because of the enormous increase in network short-circuit capacities, little knowledge was to be derived from experience in service. They thought that it was impossible to do a short-circuit test on a large transformer while maintaining the rated line voltage as required generally by present-day standards. Therefore, since the ability of a large power transformer to withstand a short circuit in accordance with existing standards could neither be arrived at theoretically nor proved practically, they thought that these standards should be revised. They concluded that the transformer user should state the maximum anticipated short-circuit capacity of the network in which the transformer was to be installed.

A theoretical approach to the subject was made by Mr. W. Knaak (Germany) in his paper on mechanical stressing of transformer windings under short circuit. He gave methods of computation for deriving lengths of cross leakage paths, taking account of the influence of winding curvature and the mechanical properties of the materials involved. The treatment, however, could not be claimed to be comprehensive. During the discussion of the papers, Mr. Langlois Berthelot (France), emphasising the complexity of the subject, posed the question of whether the axial forces and the force distribution could be determined in view of the discrepancies apparent in some of the accepted formulæ. He suggested that, while it would be virtually impossible to do a full-scale short-circuit test without risking severe damage to the transformer, it might be possible to apply a series of limited short circuits and thereby synthesise a fault equivalent to a full short circuit.

Mr. Pichon (France) disagreed with the contention that the forces could not be calculated with sufficient accuracy. He affirmed that usable formulæ, with practical coefficients had been worked out. The calculations were, he admitted complex, but they could be dealt with by modern electronic computers at a speed which made the operation remunerative.

#### Overhead Transmission Lines

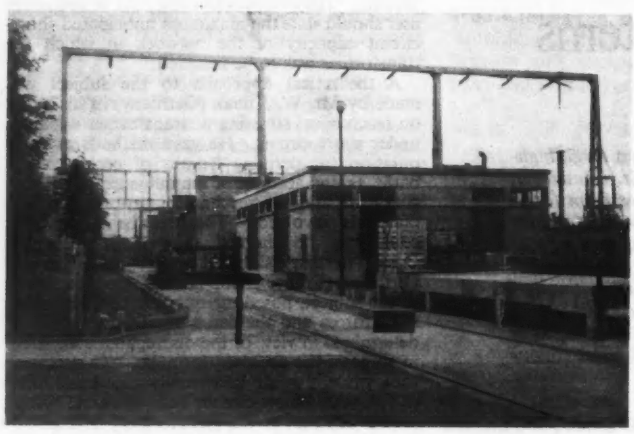
Fifteen papers on overhead lines were discussed at another meeting on Thursday, May 31st, under the chairmanship of Mr. G. Silva (Italy). The papers were divided into three main groups, the first of which focused the discussion on experimental methods of assessing the action of wind on overhead conductors. In the second group of papers, ice loading formed the basis of the discussion. These two topics have engaged the attention of C.I.G.R.E. for many years with the object of obtaining data whereby existing official specifications in various countries might be revised and correlated to permit tower weights to be reduced without affecting safety or service reliability. Insulation, stringing and line equipment and miscellaneous matters were discussed in the third group of papers.

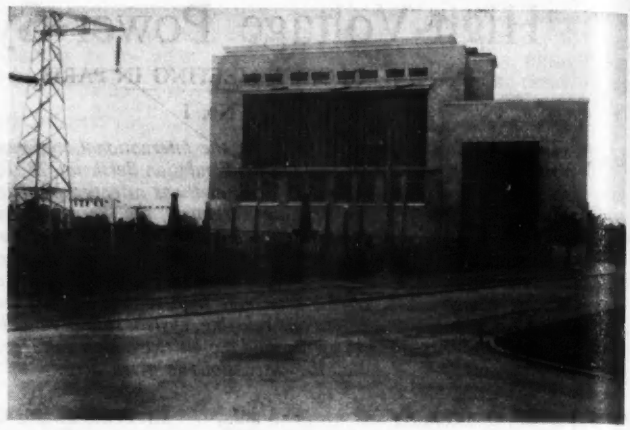
Mr. G. H. Marchal (Belgium), who opened the discussion, stressed the need for re-appraisal of test conditions and interpretation of results to co-ordinate the test practice in various countries. Much closer agreement was required on a number of matters such as methods of measurement of wind velocity, and definitions of average values of velocity and turbulence.

Mr. A. A. B. Martin (Great Britain) gave an account of wind and ice loading conditions on overhead transmission lines operated by the North of Scotland Hydro-Electric Board. He said that icing conditions in parts of the North of Scotland at about 2000ft above sea level could, because of moist conditions, be at least as bad as at much higher altitudes elsewhere. Such conditions might apply only locally: for example, they affected a 2-mile stretch of a 150-mile line on the west coast on a mountain pass at 700ft above sea level. There conductor ice coatings up to 9in across the major axis and 7in across the minor axis had been experienced, while the bases of some towers had been solidly iced up. As a means of obtaining additional heat for de-icing it had been proposed to provide light insulation between three of the strands of the a.c.s.r. conductor and the remaining thirty-four strands. The ends of the section of line so treated were to be provided with isolators so that current could be forced through the three strands.

Mr. Dienne (Belgium) described some tests carried out in Belgium on the effect of wind. Two methods of assessing wind load were used: first by measuring the angle assumed by insulator strings and, secondly, by measuring the displacement of a counterweight; the former method gave higher values. His results agreed reasonably with those of the French and an average wind load value of 50 lb per square yard of projected area could be accepted.

Mr. Birresdorf (U.S.S.R.) gave a description





**Figs. 1 and 2—Fontenay Research and Testing Centre, Electricite de France. (Left) New laboratory for equipment testing. Behind it are the open-air test bays for circuit breakers, with 225kV overhead line (Right) High-voltage laboratory with 225kV overhead line supply**

of a recording anemometer and developed a formula for measuring wind velocity.

The possibilities of reducing design requirements under wind loading conditions were discussed by a number of speakers. Mr. G. B. Simpson (Great Britain), for example, thought that numerous series of wind measurements which had been made in Europe provided a sound basis for a general reduction in design requirements. On the subject of factors of safety for lines and towers it should be possible to bring British practice more into line with American and Canadian. He thought that the design adopted for the Snowy Mountain scheme, allowing for both ice and ice-free conditions, might afford a basis for rationalisation. He wondered to what extent one was justified in designing for exceptional ice and wind conditions and he suggested that the emphasis should be on minimum statutory requirements.

Mr. G. B. Jackson (Great Britain) commented on Britain's reputation for a conservative approach to wind loading and factors of safety as laid down by regulation. From the service record of overhead lines it might be deduced that Britain was over-designing. Bearing in mind the main requirements of safety and security of supply, was it possible to reduce the margins by taking a calculated risk ? If such a calculated risk were accepted, how many structural failures due to wind loading could one tolerate per 100 miles per annum ?

Mr. G. Segre (Italy) described a method of measuring wind loading with the help of a hydraulic dynamometer fitted with maximum indication and installed experimentally between the insulator string and cross arm on certain Italian lines. Wide variations, with winds up to 90km per hour, had been recorded on this dynamometer and abnormal conditions were obtained more frequently than had been expected.

Mr. R. S. Arnot (South Africa) emphasised the importance of closer study of meteorological conditions and quoted experience with a 0·1 square inch copper double circuit line erected in Northern Rhodesia in 1938. When the need arose recently for restringing to increase the capacity of the line it was at first thought that new towers would be necessary. This conclusion was based on the supposition of incidence of maximum winds between 4 am. and 8 am., the only times when ice loading was possible. But meteorological records over many years showed that no measurable winds occurred between those hours. It was therefore possible to take a calculated risk by retaining the existing towers, ignoring the chance of coincidence of ice and wind.

Mr. Kopeliovitch (Israel) said that for about five years, he had been working to British standards, but with a reduced factor of safety. During that time the practice had been adopted on about 200 miles of lines with steel towers and 1000 miles with wooden poles, with satisfactory results.

### Fontenay Research and Testing Centre

On Wednesday, June 6th, we visited the Fontenay Research and Testing Centre of Electricité de France. It will be recalled that this installation includes a high-power testing station, an overhead line testing division, a cable testing station, and an extra-high-voltage laboratory. The facility which distinguishes the testing centre, however, making it in many ways unique, is that direct tests can be made on circuit breakers and other equipment, by connecting them to the E.D.F. 225kV system via the adjoining Chatillon substation.

From this substation 225kV supplies are taken via line circuit breakers to overhead busbars feeding all the testing stations in the area, including the main outdoor test areas. Back-up circuit breakers are installed to protect the system against failure of any of the test circuit breakers to clear a fault. Symmetrical three-phase short circuit capacities of 3500MVA (later to be increased to 4500MVA) can thus be obtained for test purposes at 225kV, the equivalent capacity at 170kV being 2500MVA. Lengths of 225kV lines up to 500 miles can be energised or de-energised from the testing station, corresponding to a three-phase, reactive power of 180MVAR. Reactive power is also available for magnetising current tests at 130kV. A single-phase 25MVA, 130/60/7kV

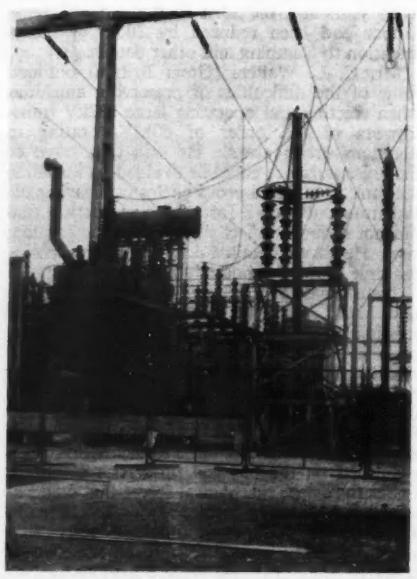


**Fig. 3—Single-phase 25MVA transformer for supplying reactive power to the high voltage test bays at Fontenay**

transformer associated with this facility is shown in Fig. 3.

Other typical views of the Fontenay centre are reproduced here. They include some of the new installations that have been put into service since our last visit to the centre in 1952. For example, four special test transformers (Fig. 4) for indirect testing were commissioned early in 1953. They are single-phase transformers with three windings : primary 132kV, secondary 4×15kV, and tertiary 4×10kV, the short-time rating of each winding being 500MVA for a few seconds, and the average reactance 25 per cent. Each of the transformer tanks is insulated from earth for 132kV and the primary windings can be connected for indirect testing at 264kV or 528kV phase-to-phase with the mid-point solidly earthed.

A new test building (Fig. 1) was completed in 1954 to provide facilities under cover for special work including heating tests, overcurrent tests and mechanical tests on equipment and accessories. The same illustration shows the overhead busbars and, behind the new test building, the open-air high-power testing station with the walls which divide the area into four bays.

A view of the high-voltage laboratory as seen from the south is reproduced in Fig. 2. The folding doors in the south wall open on to the outdoor test areas which are equipped with an experimental overhead line and cable testing facilities. As can be seen from Fig. 2, a 225kV supply is brought into the south wall of the laboratory building by overhead line. The main equipment in the high-voltage laboratory* includes a 3500kV, 80kVsec, fourteen-stage, impulse generator with a 250kV rotary rectifier ; a 50 c/s, 1000kV, 2000kVA impulse generator and a capacitor voltage divider ; a bank of

*The Engineer, June 20, 1952, page 835.

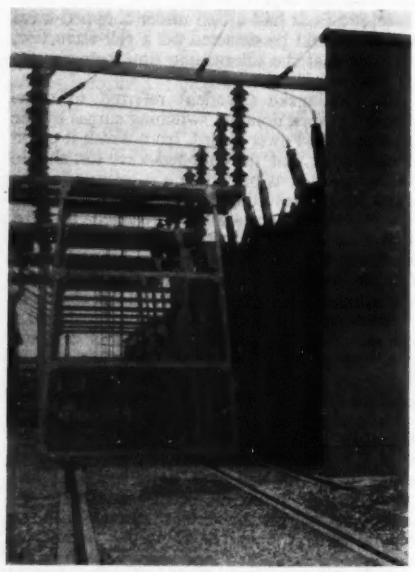


**Fig. 4—Four test transformers for giving indirect supplies to the high power test area at Fontenay**

20×1μF capacitors with mobile stands; a 100kV, 40kWsec impulse generator with rotating spark gap for impulse synchronisation; a 450kV, 1·25kWsec impulse generator arranged as a self-contained mobile unit, and two smaller impulse generators. The laboratory building also houses a well-equipped oscillograph room, a generator room, and an air-conditioned test room with provision for wet and dry testing at temperatures from −30 deg. Cent. to +60 deg. Cent. The main hall is overlooked by observation galleries and a special observation lift which can be stopped at any desired level.

Overhead line testing is carried out in an area to the east of the high-voltage laboratory. A new laboratory which is being built there is equipped with a mechanical testing plant for applying tensile or compressive loads to insulators, conductors and joints up to 3m in length, and a transformer for 50 c/s dielectric tests up to 200kV. The outdoor installation includes two foundation blocks 120m apart equipped for tensile tests up to 30 tons on conductors, &c., up to 100m long, and a high-voltage line on two medium height anchorages providing a span of 200m.

Underground cable tests are carried out in two areas and include comparative 225kV tests (which were started in 1949) on six different types of cables and a 400kV cable test on a 45m length of high-pressure, oil-filled C.d.L. cable. In the south cable test area (part of which is shown in Fig. 5) tests are in progress as part of a

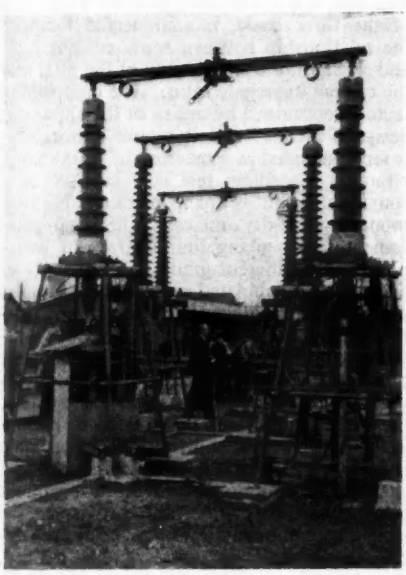


**Fig. 5—Part of the south cable test area at Fontenay**

preliminary programme on 132kV submarine cables for the proposed cross-Channel link between France and Great Britain. Glover type pre-impregnated paper-insulated gas pressure cables and an Enfield type gas compression cable are being tested. The tests include a dielectric withstand test at the phase voltage of the 225kV system.

One of the more recent additions to the facilities of the Fontenay centre is the capacitor testing station, which has been in operation about six months. The installation includes two test areas where slow ageing of capacitors can be studied. There is also a Faraday cage supplied at variable voltage from a 100kVA motor generator set where rapid ageing and medium voltage measurements can be carried out. In the capacitor building there is a measurement room adjoining the Faraday cage where measurements of loss angle, ionisation levels and residual currents can be made. A separate bay is provided for the dismantling and inspection of capacitors after breakdown under test or in normal service. There is also a small laboratory intended for work on lightning arrestors for protecting telecommunication circuits.

*(To be continued)*

## Newcomen Society's Summer Meeting

MEMBERS of the Newcomen Society assembled for the summer meeting, on the evening of May 29th, in Birmingham, where the Society was founded thirty-six years ago. The main reasons for visiting this city and the Black Country again were, first, to see certain industries before they disappear and, secondly, to inspect the exhibits in the Birmingham Museum of Science and Industry. The first visit on May 30th was made to the works of Isaac Nash Belbroughton, Ltd., at Belbroughton, near Stourbridge, where the sign of the crossed scythes over the clock proclaimed this to be a scythe works; it is the only one in the Midlands, and the original industry here is recorded as far back as early sixteenth century. Various hand processes were seen in the smithy for making scythes and billhooks; the old waterwheel and tilt-hammer are still there, but no longer used, being replaced by motor-driven Bradley hammers. The distinctive shapes of finished products used in various countries and even in different English counties were exhibited. The members then visited Middle Mill nearby, belonging to the same company, to see the last waterwheel tilt-hammer in the area, worked by one smith only, Mr. Moore, who forged scythe blades into rough shape from welded composite bars. The visitors appreciated the notice chalked on the door of the little antiquated mill, "Middle Mill Hotel now open after redecoration."

The party then drove to Bromsgrove and stood by the Lickey Incline, where Mr. C. E. Lee (vice-president) briefly explained the significance of this historical railway gradient of 1 in 37, over 2 miles long. It is on the main line from Birmingham to Gloucester and was opened in September, 1840. A longer route with an easier gradient could have been chosen, but it would have missed several towns. Members were fortunate in seeing the Bristol to Newcastle train of ten coaches start up the incline, drawn by a 4-6-0 Western Region express locomotive and simultaneously banked by two 0-6-0 tank locomotives.

After luncheon the party visited the works, founded in 1751, of the Worcester Royal Porcelain Company, Ltd.; small parties led by efficient guides appreciated the hand-painting and other processes used in the production of the beautiful bone china and figurines for which this works is famous. Members visited the Perrins Museum and admired the valuable exhibits, covering the past two hundred years, as explained by Mr. C. Shingler, the curator. As time was running short, the members divided, one party making a tour of Worcester Cathedral and its Norman crypt, and the other party visiting "The Greyfriars," the historic timbered house in Friar Street, built about 1480, and recently restored after years of neglect, through the generosity of Mr. and Miss Matley Moore. In the evening members assembled at the Birmingham Reference Library, where a very interesting selection of drawings, letters and photographs from the Boulton and Watt collection had been arranged by Miss W. Payne, the assistant librarian in charge of them. She explained briefly the scope of the collection, presented to the city in 1911 by Mr. George Tangye, who bought it in 1895 at the sale of Soho Foundry.

On May 31st a visit was paid to St. Mary's Parish Church, Handsworth, where the president of the Society, Mr. A. Stowers, gave a short address on the three famous men of Soho, buried there, Matthew Boulton, James Watt and William Murdock. The rest of the morning was spent in the Birmingham Museum of Science and Industry, where the visitors were welcomed by Dr. Mary Woodall, director of the City Museum and Art Gallery; Mr. N. W. Bertenshaw, keeper of the Museum of Science, which is, of course, a branch of the City Museum, gave a brief introduction. Members were deeply impressed by the progress made since the Museum building, formerly Elkington's Works, was occupied in 1950, and were particularly interested in the 12 h.p. Ruston-Proctor portable engine made at Lincoln about 1890, recently restored by Mr. A. J. Kent and now working under steam; they also examined the exhibits in the engineering hall, transport gallery and collections of machinery, and the electrical apparatus, some of which was demonstrated by Mr. C. H. H. Franklin. In the afternoon the party visited the Netherton Ironworks, founded in 1838, of N. Hingley and Sons, Ltd., and were received by Mr. P. Jump, chairman of the Society's Midland branch. As time was limited, the attention of members was concentrated on watching the strenuous manufacture of wrought iron in the puddling furnaces, and the hand welding of wrought iron chain. Two steam engines of particular interest were the 398 i.h.p. beam engine, 44⅛in bore and 7ft stroke, built by N. I. W. Holcroft and Co., Bilston, over a hundred years ago and still driving rolls for wrought iron bars; and secondly, a very small Murray's cycloidal engine, possibly the last in Europe incorporating Matthew Murray's ingenious straight line motion of 1802.

Arriving next at the Bilston Iron and Steel Works of Stewarts and Lloyds, Ltd., the party was received by Mr. W. M. Larke, works manager, who paid a tribute to the pioneer work of the late J. H. Hamilton on the design of large gas engines. The sight of nineteen large horizontal Premier tandem engines, all running on blast-furnace gas and with Hamilton's positive scavenging cylinders, was most impressive. Thirteen of the engines were coupled to generators and six had blowing cylinders. The sizes varied from 2000 h.p. to 350 h.p. and the earliest engine was made in 1903. At the Society's annual dinner in the evening the president, following the loyal toast, proposed the traditional toast to the memory of Thomas Newcomen, and finally the toast of "The Guests," on whose behalf Mr. Bertenshaw responded. After dinner Mr. Jump projected a selection of his short documentary films showing the production of wrought iron chain and anchors in his works; as some of the processes have been obsolete for years, the films are now of considerable value historically.

On June 1st visits were made to the two cast iron bridges over the River Severn, viz., the first in the world, erected at Ironbridge in 1779, on which Dr. S. B. Hamilton gave a brief account of its history and construction, and the other at Coalport, built in 1818. At the nearby works of the Coalbrookdale Company, Ltd., members saw the remains of a blast-furnace dated 1777, which, Mr. W. K. V. Gale explained, was believed to have been built by Abraham Darby III to produce iron for the famous cast iron bridge of 1779. In the afternoon the party visited the Lilleshall Iron Works near Oakengates and saw the impressive pair of beam blowing engines in classical style, with steam cylinders 38½in diameter by 7ft 10in stroke, which were built in 1851 by Murdock, Aitken and Co., Glasgow, and worked till 1900. Even more monumental was the 400 h.p. vertical tandem compound engine with blowing tubs in tandem at the top, the overall height being 44ft. This was designed and built in 1900 by the Lilleshall Company itself, but is now kept as standby plant to the turbo-compressors. On the return journey members visited the British Waterways Repair Yard at Ocker Hill, Tipton, and paid homage to the Watt beam pumping engine preserved there under the care of Mr. J. H. Osborn. Built by Boulton and Watt in 1777, it was erected at the Birmingham Canal Navigation's pumping station at Smethwick, was tested by Smeaton in 1778 and worked there till 1898, when it was rebuilt at Ocker Hill. During the Watt Centenrary Commemoration in 1919 indicator cards were taken on this engine, which is the earliest complete Watt engine in existence.

On June 2nd some of the members drove to Hartlebury, near Stourport, to inspect Mr. F. P. Middleton's private collection of ten steam portable and traction engines. Two were under steam, the chief attraction being the showman's engine "Winston Churchill," made in 1922 by Charles Burrell and Sons, Ltd., Thetford, and resplendent with its gilded pillars and bright colours. Other engines were the products of Burrell, Foden, Clayton and Shuttleworth, Humphries, John Fowler and Garrett.

Thanks to months of preparations by Mr. Jump, Mr. Gale and Mr. T. F. Luck, of the Birmingham committee, the meeting, held in good weather and attended by about fifty members and friends, was most successful.

# LETTERS AND LITERATURE

## Letter to the Editor

*(We do not hold ourselves responsible for the opinions of our correspondents)*

### THREATENING TAX

SIR,—A close study of the Finance Bill has revealed that a clause which can have but little significance to the country's revenue will effect a fundamental change in the activities and authority of the Inland Revenue. There can be no doubt that Purchase Tax is a valued feature of the present Government's revenue structure. The last Budget saw a small extension of the variety of goods liable to this tax, but the Finance Bill, soon to come before the House, renders an entirely new range of activities taxable. As readers connected with industry will be aware, the name "Purchase Tax" is misleading, in that it is the manufacture, and not the sale, of an article that incurs taxation. In an attempt to levy a higher rate of tax upon those private cars which come into being by conversion from commercial vehicles, the Chancellor proposes to render taxable the construction of a car, truck, motor cycle, or other vehicle by anyone not normally engaged in the manufacture of motor vehicles. In view of the fact that the construction of a self-propelled vehicle involves a high degree of proficiency in a number of specialised techniques, it may well be thought that this is such an infrequent occurrence that the clause is unimportant: that is not my opinion.

Engineers within the motor industry will be taking a short-sighted view if they welcome a measure of protection from competitors with negligible overheads. An industry that is selling to a multitude of customers benefits to an immense extent from an educated, interested and sympathetic public. Any man who has built a vehicle of his own will have a lively awareness of the difficulties of design and the delays of development, and will have a reasoning respect for reliability and refinement. He, and his interested intimates, represent a nucleus of highly informed customers, as well as being actual customers to the ancillary branches of the industry. Other readers, even if they do not contemplate building a special works truck for their factory—tax is payable on vehicles which are not registered for use on public roads—may wish for a warning that, if Parliament passes this provision, it will have approved, in principle, the collection of tax upon the toys they make for their sons, and on the clothes their wives machine at home from patterns.

This remarkable proposal springs from the confused classification of "private" and "commercial" vehicles. At present a platform truck can have windows all round its cab, though since the driver can bring his head to the rear window these are not usually provided, while the driver of a van is forced to manœuvre his much more vulnerable vehicle with a restricted field of view. But while a vehicle with side windows behind the cockpit is unquestionably a private car to the Commissioners of Inland Revenue, the Ministry of Transport do not accept that it is necessarily exempt from the speed limit on commercial vehicles, while for purposes of insurance nothing less than a detailed investigation of vehicle, freight and driver can determine the distinction. One of the dangerous results of such a situation is the proposal I have discussed above. Another which I can see becoming important, since the Minister of Transport is proceeding with the project to test the serviceability of road vehicles, is that there is no clear way to distinguish between private cars, many of which probably do not total mileages of five figures in a year, and commercial vehicles which, to earn their cost, will be utilised an order of magnitude more intensively. The Minister of Transport and Civil Aviation appears to be ready to accept increased powers and duties, in return for which he offers a possible partial withdrawal of the speed limit on commercial vehicles. Once he has the ability to require a certain level of performance in braking, cornering and lighting, it is less than clear why he should be allowed to perpetuate this classic among "restrictive practices." In the meantime, he could well apply his existing powers and influence to establishing, beyond the cavil of the Chancellor, what is a car, and what is not.

S. GRIEVESON

Darlington, June 11th.

## Literature

*Concrete Roads: Design and Construction.* H.M. Stationery Office, for D.S.I.R., York House, Kingsway, London, W.C.2. Price 25s.

THIS authoritative book has been compiled by members of the staff of the concrete section of the Road Research Laboratory and forms a companion volume to *Soil Mechanics for Road Engineers*, published in 1952. It is well known that the Road Research Laboratory, under the direction of Dr. Glanville, maintains a close relationship between scientific investigations and the practical application of the results derived therefrom, and this admirable principle is reflected in the book itself. Consequently it will be found of great value to the site engineer concerned with the construction of concrete roads and runways as well as to the designer. The ingredients for making concrete are dealt with first, and references are given to the British Standard Specifications for cements and aggregates, with short extracts relating to testing methods and specified requirements. The aggregate crushing and impact tests, developed at the Road Research Laboratory, are now accepted standards in place of the older tests associated with road stones, and it is not surprising to learn that the impact values of brittle aggregates, such as flint, are higher than their crushing values, high values in the new test indicating poor quality. Very high crushing strengths could be obtained with careful loading on prepared specimens of flint, but its brittle nature would be instantly revealed in the Page impact test. The standard caustic soda test for organic impurity in aggregates is briefly mentioned, but this test has occasionally been found ineffective in detecting small amounts of organic pollution which have prevented the hardening of soil-cement mixtures.

The testing of concrete is considered next and naturally leads to a discussion of the relative merits of crushing strength and flexural strength as criteria of concrete quality. It is agreed that crushing strength does not give a complete indication of the fitness of the material, although the concrete crushing test is recommended as a final test for sands suspected of being organically impure, thus casting doubt on the caustic soda method previously mentioned. The flexural test provides a closer approach than the crushing test to the usual conditions of failure of road slabs, and investigations carried out at the Road Research Laboratory confirm the opinion commonly held in the United States that the flexural test is more sensitive in showing the effect of different kinds of aggregate in the mix. In the succeeding chapter, headed "Physical Properties of Concrete," there is a very interesting comparison of crushing, flexural and tensile tests and some useful data relating to drying shrinkage and thermal expansion.

One of the more valuable chapters in the book is that devoted to the design of mixes. This contains the clearest possible exposition of the three basic, interconnected factors: the relationship between water-cement ratio and strength, the workability of the mix, and the cement-aggregate ratio. The compacting factor, determined by means of the apparatus designed at the Road Research Laboratory, is recommended as a measure of workability, although the slump test may be used as a rough guide, but is apt to be unreliable with modern ultra-dry mixes. The aggregate-cement ratios giving four degrees of workability with different gradings and shapes of aggregate are tabulated, and worked examples are included to illustrate how various aggregates may be combined to provide satisfactory gradings. Variation in concrete quality is discussed at some length. This unfortunate characteristic is, to some extent, inevitable, but it may be reduced to reasonable limits by strict control. Weigh batching is recommended and one is very glad to find that the authors do not advocate it without adding a most important proviso: the weighing equipment must be accurate, frequently tested and properly maintained. Weigh-batching with inaccurate and badly maintained plant is likely to result in wider variations in the quality of the concrete than careful volumetric batching, particularly if the sand is tested from time to time for moisture content, and due allowance made for bulking. An elaborate table given on pages 106 and 107, showing the variations in crushing strength observed on different jobs, with different degrees of control, does not appear to provide convincing evidence of anything definite, but considering all the variables involved this is only to be expected.

Coming to the question of durability and resistance to chemical attack and frost, the fact is emphasised that the best protection is to use methods which will ensure that the concrete is of high quality. These consist of thorough mixing, correct grading, with the lowest possible water-cement ratio, and full compaction, followed by proper curing. The use of air-entrained concrete is discussed without much enthusiasm, and it is suggested that there is no justification for the large-scale adoption of this process for machine-laid roads in Great Britain. It has become popular in the United States as a preventative of frost damage, but our winters, presumably,

are not sufficiently severe to warrant its use here. Nevertheless, it is agreed that air-entraining increases workability and enables the sand content in the mix to be reduced. This in turn makes it possible to reduce the water-cement ratio, thus compensating for the reduction in strength which air entraining usually causes. There is a brief reference to the various additives which are sometimes employed to impart special characteristics to a mix, or in an attempt to economise in cement, and the mention of finely divided materials in this latter connection recalls a claim, made some years ago, that finely pulverised granite dust could be used to replace a proportion of the cement and would give remarkably high compressive strengths.

The second part of the book deals with the concrete road regarded as a structure. Westergaard's well-known analysis of the stresses in a concrete road slab, together with the modifications introduced by Teller and Sutherland, are concisely summarised, and Thomlinson's method of calculating temperature gradients and the resulting stresses is given in some detail. It is pointed out, however, that it is not possible to design road slabs completely from stress calculations, a statement with which practical road engineers will fully agree. It is considered that static loading produces higher stresses than dynamic loading in concrete roads, and investigations into the stresses produced by stationary and moving vehicles in flexible pavements confirm this view.

A noteworthy feature of this section of the book is a table of traffic classifications, ranging from "very heavy" to "exceptionally light," based on the daily flow of commercial vehicles and the approximate total weight of vehicles of all kinds using the road during the same period. This classification is supplemented by tabulated data giving the recommended slab thickness and the amount of reinforcement to suit each intensity of traffic loading for a complete range of subgrades. This, indeed, is concrete road design reduced to the simplest possible terms. There is a prevalent opinion that the uniformity of the subgrade is of greater importance than its shear strength, or bearing capacity, when considering the thickness required for the superimposed road slabs. This, surely, is a somewhat sweeping assertion, but it is given support in the present book, although C.B.R. values are quoted for some of the subgrade types included in the above table, which rather suggests that bearing capacity has some influence, after all.

Prestressed concrete roads are dealt with very briefly, only seven pages or so being devoted to this subject, compared with thirty-two which are occupied by the vexed question of joints, and a further eighteen describing filling and sealing materials for these troublesome items in concrete road design.

There is a curious divergence between the recommended practice given in the book and a reported trend in American methods: the authors suggest that contraction joints are unnecessary if the slabs contain specified amounts of reinforcement, although the omission of these joints would imply that expansion joints would be needed at closer intervals. It is mentioned, however, that in certain American states expansion joints are being dispensed with and dummy contraction joints inserted at 15ft intervals. It is notoriously unwise to compare British and American practice too closely, owing to the difference in conditions which often prevails, but this complete antithesis of opinion is remarkable.

A useful chapter on "Defects and Maintenance" follows the excellent chapters on joints and joint fillers. Maintenance includes the removal of snow and ice, in connection with which it is stated that salt may be used, but care must be taken to avoid damage to the road surface. One might well add that salt can cause considerable damage, also, to the chromium plating of passing vehicles and to the metallic piping of their hydraulic brakes.

The third part of the book is concerned with the use of machinery for concrete road construction and contains four chapters. The first gives a general survey of the plant in common use for mixing, placing, and compacting concrete. Details of individual machines are omitted but some useful figures are included relating to outputs and costs. The second chapter is devoted entirely to the performance of mixers, and attention is drawn to the fact that while most machines have proved reasonably satisfactory for wet mixes, difficulties are being experienced with the very dry mixes used for roads and runways in conjunction with vibratory compaction. Although the results of tests must necessarily depend, to some extent, upon the design features of different makes of machine, it has been possible to distinguish between the performance characteristics of the main types. Thus, the non-tilting type has been found to produce more uniform mixes than the tilting type, but the average mix proportions were found to be closer to the specification figures when tilting-drum mixers were used. The third chapter in this section describes in some detail an interesting and valuable research investigation into the efficiency of various compacting machines and the effects of varying the amplitude and frequency of vibration.

The fourth chapter deals with the effect of different constructional methods on the riding quality of the finished surface. There is a general impression, not without justification, that the riding qualities of machine-laid concrete are inferior to those of the best hand-finished surfaces and have never reached the near perfection of certain machine-laid bituminous carpets. The reasons for this are discussed and suggestions made for securing a higher standard of workmanship. A very useful list of testing apparatus for both permanent and mobile laboratories is added, together with a glossary of technical terms and symbols.

Mr. F. N. Sparkes, head of the concrete section at the Road Research Laboratory, and all who have contributed to the compilation of this most informative book, must be congratulated on an excellent piece of work.

*The Foreman's Handbook*. Edited by CARL HEYEL. London: McGraw-Hill Book Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, London, E.C.4. Price 49s.

THE general purpose of this book is to enable a foreman to meet the problems that confront him in his daily work and to cope with them efficiently, and at the same time to widen his outlook and to help fit him for promotion. Not only does this work describe what a foreman is expected to know, but it also examines the background information and the attitude he must develop to prepare him for greater responsibilities. The various chapters are written by different authors, each an expert in his particular sphere; each chapter can be read independently of the others, although all are interrelated. The foreman who possesses the knowledge he would appear to be expected to acquire would indeed be a paragon for, in addition to the duties normally attributed to him, he is supposed to take his part in the planning and scheduling of work, to have a knowledge of time and motion study, of the predetermining of standards, of the different systems of incentive, of cost control, of merit rating, of work simplification, of industrial psychology, and at the same time be efficient in training an understudy, as well as the new hands entrusted to his charge, bearing in mind that "every learner failure must be regarded as an instructor failure." Certainly there are very few managers who could claim to have mastered all the contents of this somewhat exhaustive handbook.

In the first chapter Mr. Heyel gives a useful breakdown of the foreman's job, and we are glad to note that he insists on the foreman being recognised as part of the management, a state of affairs that does not frequently obtain, and again the necessity for his being aware of the company's policy, so that he can answer intelligently questions that may be put to him. The book is divided into seven sections, each section, apart from section six, having two to four chapters dealing with different branches of the main subject. Section six is devoted to work simplification by the foreman, and although not subdivided into chapters, it has forty-four pages devoted to it, indicating its importance. After the description in the first section of the scope of the foreman's job, the second clearly sets out what he is expected to know, including the important matter of quality control, which is increasingly coming to the fore; other subjects to which allusion has already been made are also discussed. Section three is devoted to the foreman's direct personnel responsibilities, including training, safety measures, industrial fatigue, and the special problems connected with the supervision of women.

The fourth section sets out his responsibilities in co-operating with other functions, a very thorny subject, but it is essential to know exactly where responsibilities begin and end. Section five is entitled "Background Information for the Foreman," and it introduces him to the principles of scientific management, and the forms of industrial organisation, while it suggests what he should know about economics, and the various measures which have been brought in by the Government. The last section calls itself "Self Quiz for Executive Development" and contains a series of questions on each chapter, followed by a key indicating where the answer may be found. Special attention has been devoted to job evaluation, quality and waste control, predetermined time standards, and the "standard minute" system of wage incentive payment, now widely applied in the United States. Such is an outline of a book that is calculated to be very valuable to an intelligent foreman.

The authors give some very salutary advice to the foreman, especially as to handling people, being ready to show recognition of work well done, and being clear as to the policy to be followed. It is rightly stated that "courtesy can be a lubricant of good will." We are glad to see the stress that is laid on the prompt handling of grievances, for too often matters are left to slide and become aggravated when a little early investigation and consideration might have effectively cleared the air. We agree that frequently foremen are not allowed a say in the planning and scheduling of work, whereas their advice would often be very valuable, while they on their part should not leave everything to the time study man, but should be ready to offer practical suggestions. Whether he should be concerned with the different methods of payment by results is

debatable, as the type adopted will be decided for him. It is felt that the author is somewhat severe in his opinion of straight piecework, in that it is much favoured in this country, where different forms of bonus are often viewed with suspicion. If a foreman is to take a real interest in cost control it is essential that statements should be presented to him in such a way as to give him the information he needs without extraneous statistics, and it is equally important that these statements are available as early as possible, for stale figures have little or no value. When dealing with the special problems that confront him in supervising women a suggestion is made that workers who need extra energy should have "Oslo meals" served in mid-morning and afternoon. They consist of wholemeal bread, cheese, half an orange, half an apple, a raw carrot, and milk. It would be interesting to know the extent to which this has been tried in Britain. The degree to which a foreman is capable of correctly assessing the worth of a man is questionable, in that often when an employee is transferred to another shop the second foreman will give an entirely different report on the merits of the man in question. We are told that the foreman is responsible for "protecting the rights of management within the framework of the laws of the land" and also for himself observing these laws. When he reads all this he need not be discouraged, but rather realise that he cannot be *au fait* with all that this book contains, provided he can appreciate where he can find advice which will help him with different problems as and when they arise.

This handbook is well illustrated with diagrams and sample forms, but in many of them the printing is so small that a magnifying glass is really necessary for studying them in comfort. *The Foreman's Handbook* will prove a useful handmaid to the enterprising and ambitious foreman, and might well find a place on the manager's table also.

*Mise en Equations et Résolution des Réseaux Electriques en Régime Transitoire par la Méthode Tensorielle.* By A. KAUFMANN. Publications Scientifiques et Techniques du Ministère de l'Air, No. N.T.56. Service de Documentation et d'Information Technique de L'Aeronautique, Magasin C.T.O., 2, Avenue de la Porte-d'Issy, Paris (15e). Price 1100 francs.

SINCE the days of Kirchhoff and Maxwell electrical outworks have become more and more complicated. While Kirchhoff's laws and the methods developed by Maxwell remain adequate in single instances, in many other cases their use is becoming prohibitive on account of the time and work involved. The author shows how the tensor method developed by Kron can be applied to the study of transients in complicated networks containing inductances, capacities, electronic tubes, rotating machinery, electrical mechanisms and other elements. The first part is devoted to the derivation of Kirchhoff's laws in the general case. These had previously been accepted without proof. It was judged necessary to base them upon solid foundations, not only for the case of linear networks represented by symmetrical matrices, but also for those cases where the matrices are non-symmetrical. In the chapters which follow it is shown, first, how parts of networks can be represented by tensors and subsequently how parts containing pairs of nodal points can be so represented. In this connection a number of simple theories are stated and examples are given in order to illustrate the process. The author proposes to distinguish, among the initial values of solutions, between those which are "inherited" from the preceding state of the system, and those which are "unknown," i.e. which do not depend upon the previous state but on external events. Lastly, the treatment includes more general cases where electromotive forces and currents are applied at the same time. Of great importance is the bibliography at the end of the book, which comprises virtually all known theoretical works on linear electric networks.

*Turbinenschaufeln aus Kunststoff für Kaltluftuntersuchungen* (*Plastic Turbine Blades for Tests Using Cold Air*). By K. LEIST and W. DETTMERING. Forschungsberichte des Wirtschafts-und Verkehrsministeriums Nordrhein-Westfalen, No. 235. Westdeutscher Verlag, Ophovener Strasse 1-3, Opladen. Price DM. 12.30.

IN the investigation of the flow around turbine blades great difficulties often arise with the siting and manufacture of the multiplicity of holes required for the detailed measurement of pressure distributions. This is particularly so in the case of long and twisted blades made from steel. Many years ago, Ackeret and his collaborators demonstrated that steam as a test fluid could be replaced by air at room temperature, provided the necessary dimensional corrections were made in the evaluation of results. If cold air is used in place of steam or hot combustion gases, then it is possible to employ blades made from plastic. In particular the use of transparent thermoplastic offers great advantages : the possibility of observing the interior of the machine in operation, and the ease of manufacture of the blading, with the required measuring channels already incorporated. The present treatise describes the methods employed at Aachen Technical University for the manufacture of plastic blades, both from "Plexiglas" and from "Araldite B," and the results of some tests which showed that the latter material could be used in combination with light alloy rings and blading, at circumferential speeds of up to 245metres per second.

*Strömung vor einem Uberschall-Laufrad* (*Flow over a Supersonic Rotor*). By H. Söhngen. Forschungsberichte des Wirtschafts-und Verkehrsministeriums Nordrhein-Westfalen, No. 247. Westdeutscher Verlag, Ophovener Strasse 1-3, Opladen, German Federal Republic. Price DM. 7.60.

THE author considers the case of an idealised model with a velocity field containing the following components : the undisturbed approach velocity, disturbances in front of the rotor caused by the blading, and the reflexions of these disturbances at the entrance. The annulus behind the rotor is infinitely long, and no reflexions are sent back to the rotor from there.

Investigation shows that the disturbances reflected at the entrance are made up of three components, viz. a reflected potential flow, a reflected vortex flow, with the vortices being carried downstream by the main flow, and a steady change of the axial approach velocity and the pressure. Calculation of the case of straight profiles placed sufficiently close together shows that disturbances emanating from the blading are just compensated by the reflected component, so that a completely homogeneous axial flow results.

The amount of flow depends only upon the angle of attack of the blades and the circumferential speed of the assembly, and is independent of the back pressure. Behind the rotor the flow is strongly non-homogeneous and therefore losses occur. It is pointed out that for at least one condition it is possible to achieve a completely homogeneous flow downstream of the blading (neglecting the effects of viscosity). This is done by choosing suitable triangular blade profiles. The author recommends the choice of straight section profiles, since curved profiles cause reflexions at the inlet and hence give rise to vortices.

*Electric Motors and Controls.* British Electrical Development Association, 2, Savoy Hill, London, W.C.2. Price 8s. 6d.

THE third book in a series published by B.E.D.A. on electricity and productivity is intended to meet the needs of management in industry by giving a simple exposition of the various kinds of electric motor and by explaining the reasons for choosing a particular kind to do a given job economically. It contains a minimum of theory to explain the principles of electric motors, followed by a wealth of concise and well-indexed information about the starting, running, speed control and reversing characteristics of all the known kinds of a.c. and d.c. motors. There are separate sections on the mechanical forms in which motors are available, and on control equipment, automatic control, installation and maintenance. The important subject of the economical use of motors is dealt with in a separate chapter discussing horsepower rating, overload and thermal capacity, speed-torque characteristics, and power factor improvement. To the user, particularly the non-technical user, this book should be a permanent reference source.

*Electrical Interference.* By A. P. HALE, Grad. I.E.E. Heywood and Co., Ltd., Tower House, Southampton Street, London, W.C.2. Price 15s.

THIS book attempts a practical approach to the subject of man-made interference with radio and television (mainly from electrical machinery). Although the emphasis is on the practical side, the book is intended to be read as a whole rather than used as a source of reference. In it the author examines the causes and effects of interference and its detection and measurement ; he then discusses methods of avoiding interference or suppressing it where it exists.

There are chapters on filters and Faraday cages and a useful bibliography is included.

### Books Received

*Circular Cylindrical Shells.* By Rüdiger-Urban. B. G. Teubner, Verlagsgesellschaft, Leipzig. Price Dm. 24.

*Rockets and Guided Missiles.* By John Humphries. Ernest Benn, Ltd., Bouverie House, Fleet Street, London, E.C.4. Price 30s.

*Guide to Belgium.* Fourth edition. By C. A. Thompson. Belux Publications, 44, Suffolk Road, Ilford, Essex, England. Price 4s. 6d.

*Stability Functions for Structural Frameworks.* By R. K. Livesley and D. B. Chandler. The Manchester University Press, 316–324, Oxford Road, Manchester, 13. Price 6s.

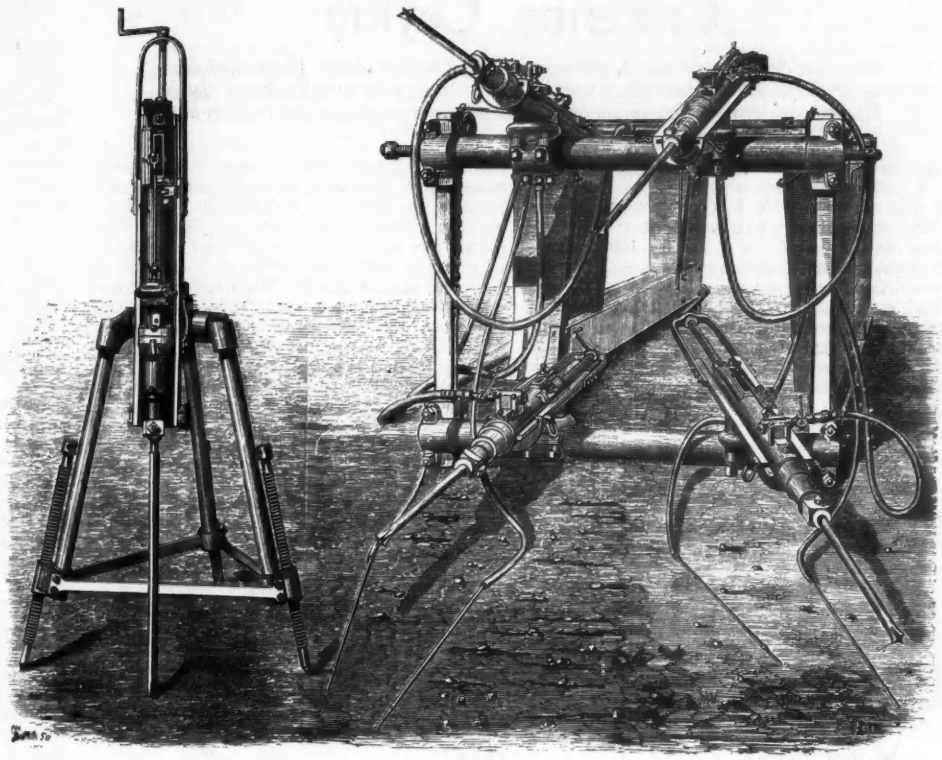
*Flow Production and Automation.* By Frank G. Woollard. Industrial Administration Group of the Guild of Students of the College of Technology, Birmingham. Price 5s.

*Cavitation in Hydrodynamics. Proceedings of a Symposium held at the National Physical Laboratory.* H.M. Stationery Office, York House, Kingsway, London, W.C.2. Price 30s.

*Report on the Multi-Purpose Plan for Permanently Controlling the Yellow River and Exploiting its Water Resources.* By Teng Tse-Hui Britain-China Friendship Association, 228, Gray's Inn Road, London, W.C.1. Price 1s. 6d.

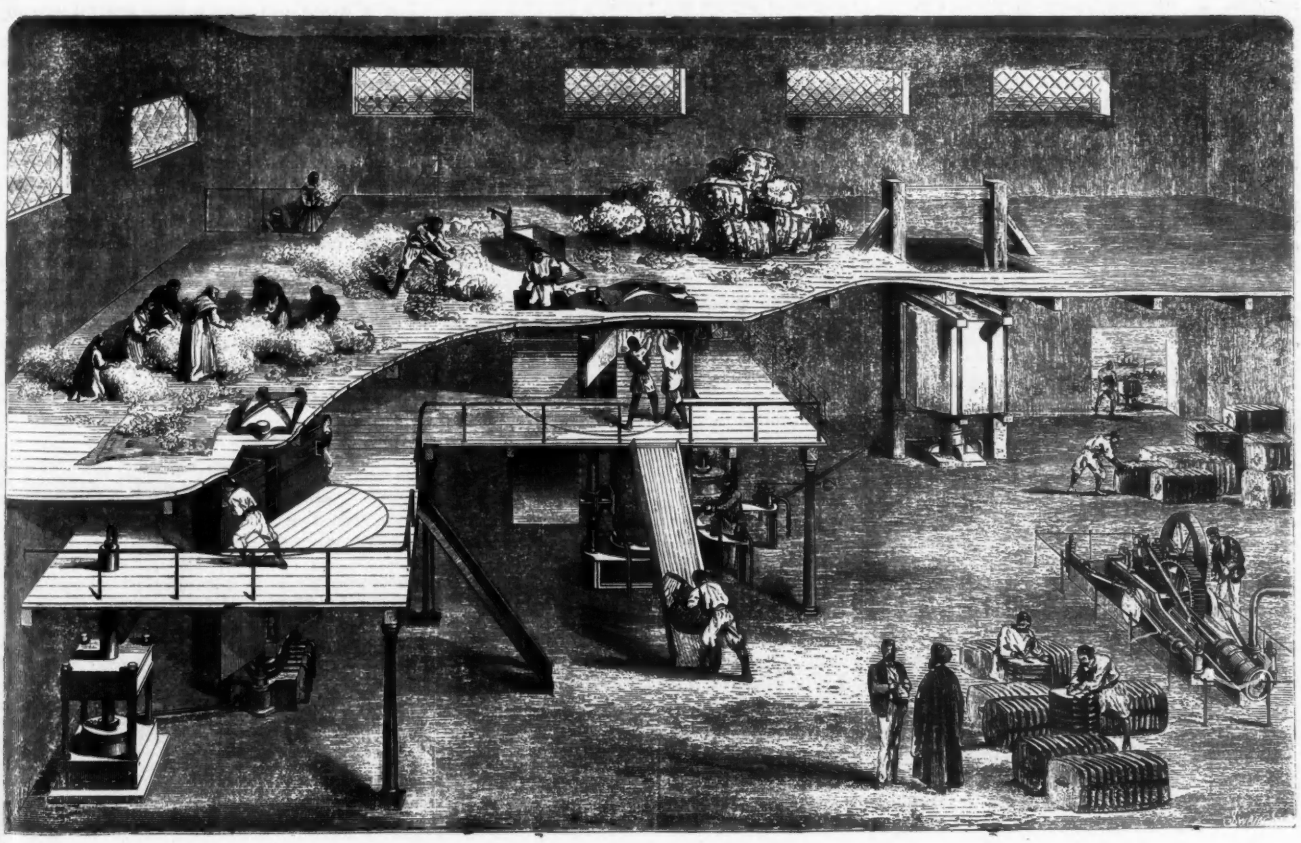
# ENGRAVINGS OF 1870

The right-hand engraving, reproduced from our issue of May 20, 1870, illustrates the Burleigh Rock Borer. There were two models of the machine; one (left) for vertical boring, and the other for tunnelling. The machine was worked by compressed air and the drills were made of cast steel.



Below, there is illustrated one of the lamp "pillars" erected on the Thames Embankment, near the Temple. The engraving is reproduced from our issue of March 18, 1870. The pillar was made by the Coalbrookdale Company and described by us as "a very ambitious work."

The Egyptian cotton "shoonah," illustrated below, was described in our issue of March 4, 1870. It contained two cotton presses which could be "conveniently worked by one accumulator, each press having a separate differential apparatus." With one machine, it was stated, "from fifteen to twenty bales per hour are packed." The "Accumulator" cotton presses were manufactured by Andrew Handyside and Co., of Derby.



# Port Development Works at Colombo, Ceylon

*Extensive development works, involving the construction of over 10,000ft of deep-water quays, and various other works, have recently been completed at Colombo Harbour. A general description of the new additions to the harbour is given here.*

As early as 1902 schemes for alongside berths at Colombo were under consideration, but it was not until 1949 that the present designs were accepted and a contract for their construction was awarded on June 28, 1950. This contract covered four major constructions and was divided into two main stages ; all of this work is now substantially complete. It has been carried out to the designs of the consulting engineers, Messrs. Coode and Partners, by the contractors, Compagnie Industrielle de Travaux (Entreprises Schneider), and Etablissements Billiard, of Paris. The new works can be identified in the accompanying plan, Fig. 1. The first stage comprised :

*The North-East Breakwater Quay*, which was previously referred to as the Mutwal Quay and is now named Prince Vijaya Quay. The length of the quay is 1232ft 6in, with a breadth of 170ft and a depth alongside of 32ft at L.W.O.S.T. The original intention was to use the quay for importing coal, phosphates and manures, but as the policy of the Port Commission was modified regarding such imports, the quay was widened to 188ft and equipped with transit sheds and warehouse facilities for the handling of general cargo.

*An Oil Dock.*—The oil dock is formed within new piers known as the North Pier and the South Quay. The North Pier is of block work construction protected on the north side with a heavy rubble bank at the outer end and a pitched slope of concrete blocks towards the landward end. The South Quay is also of blockwork construction, the outward end being returned to form an extension of the guide pier to the existing graving dock, 400ft in length. The North Pier is 1278ft in length and the South Quay 950ft, and both berths have 36ft depth alongside at L.W.O.S.T. The dock is enclosed with a floating boom of ten articulated pontoons, connected to a " Mulsifyre " pump house on the South Quay. When not in use the pontoons are housed in a dock, also at the South Quay. The oil dock will accommodate two tankers, and the oil is pumped direct to the various oil companies' depots in Colombo.

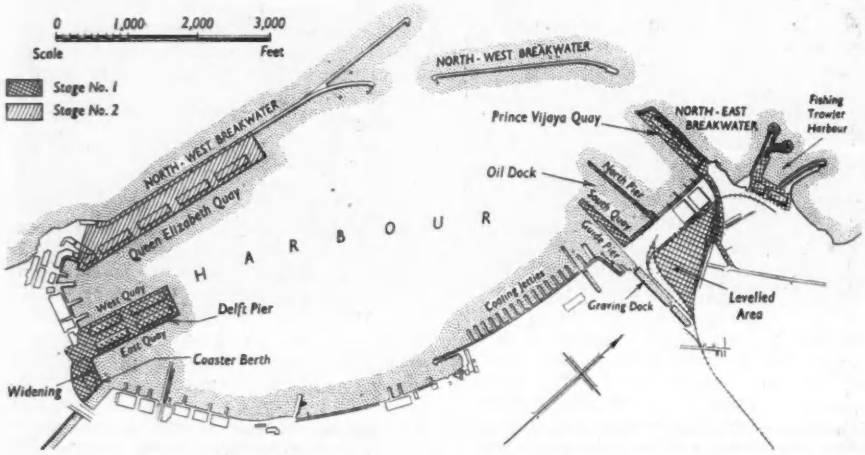



**Fig. 1—Colombo harbour, showing both stages of the new work**

*Delft Pier.*—The pier is 425ft 6in wide and is constructed at the site of the old passenger jetty. The East Quay has a length of 1384ft 6in and joins the new Delft Quay widening and the new lighterage berth, which extend to the entrance from the harbour to Lake Canal. The West Quay has a length of 1352ft 6in and the North Quay is 425ft 6in long ; the pier affords accommodation for five vessels and has a depth alongside of 33ft at L.W.O.S.T. at all quays.

Both the East and West Quays have two transit sheds of 540ft and 480ft in length respectively, with clear spans of 110ft. As the North Quay cannot be used in the north-east and south-west monsoons, sections of the two adjacent sheds were designed to allow cargo handling when the quay is in use ; otherwise, they serve the East and West Quays respectively.

The Delft Quay widening and lighterage berth are of cylinder and reinforced concrete construction with a depth alongside of 24ft at L.W.O.S.T., and the existing shedding was converted for cargo handling.

The second stage includes :

*The South-West Breakwater Pier.*—The original contract provided for the construction of the south-west breakwater pier in two stages. Before the contractors had received instructions to proceed with the second stage, the Government decided to construct a marginal quay in preference to a pier. The marginal quay, named the Queen Elizabeth Quay by H.M. Queen Elizabeth II during her visit in 1954, is 3000ft in length with a width of 400ft and a depth alongside of 36ft at L.W.O.S.T.

The quay is equipped with four transit sheds, each 500ft by 110ft clear span. A terminal building has been constructed for the accommodation of customs, medical services and port officials. Passengers arriving from and departing by vessels lying at the buoys will pass through this building. Separate buildings have been erected for port police and other services. A wave wall 14ft in height was constructed at the seaward side of the south-west breakwater to prevent the seas sluicing over the breakwater, and so across the quay, during the period of the south-west monsoons. The surface level of the wave wall is 25ft above L.W.O.S.T. There are three sets of steps leading to the upper surfaces and, being over 3000ft in length, the wave wall forms a pleasant promenade.

## Fishing Trawler Harbour

In June, 1954, the Ceylon Government accepted the consulting engineers' design for a trawler harbour, and this construction was carried out by the main contractors. The trawler harbour is situated outside the Colombo Harbour, near the existing harbour at Mutwal, and comprises a main mole with an extension to provide protection during both monsoons. The main mole has a wave wall with a top level of 19ft above L.W.O.S.T., and both the main and the extension moles terminate in roundheads with heavy rubble protection.

The trawler quay is 240ft in length with 20ft depth alongside at L.W.O.S.T. The Colombo Plan (Canada) provided the ancillary ice-making, fish storage and processing plant, but such items did not form part of the contract. The fishing trawler harbour is shown in the foreground of Fig. 5, which also gives a good general view of the main port.

## Construction of Main Berths

The berths constructed under the port development works are listed in the table. With the exceptions of the Delft Quay widening and the lighterage berth, all quay walls were built of sloping blockwork laid upon a screeded rubble foundation of 4ft minimum thickness, the superstructure being made of 7–1 mass concrete with precast ashlar facing, as were the precast coping set between the cast steel cope bollards, which were placed at 72ft to 78ft intervals.

The outer crane rails are carried upon the quay superstructure and the inner crane rails are set upon reinforced concrete precast beams supported upon precast block pillars carried upon " C " or " D " courses of blocks in the

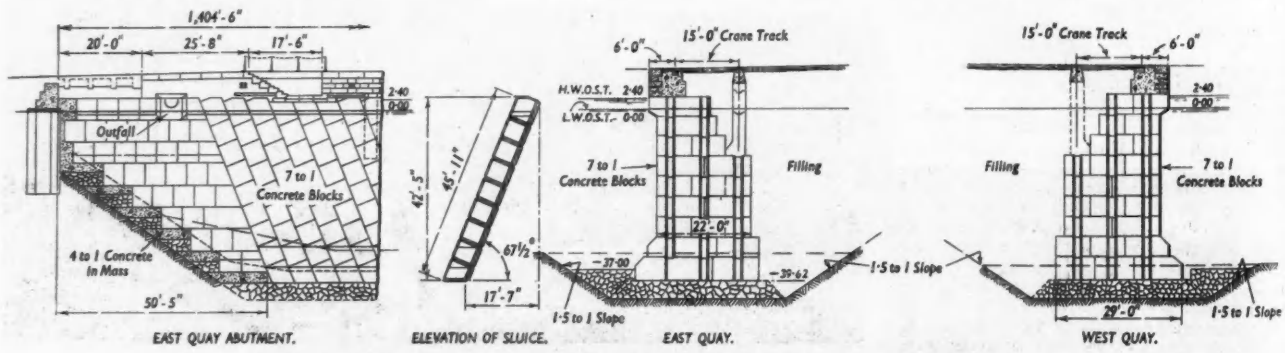



**Fig. 2—Typical cross sections of sloping blockwork. These sections relate to the Delft Pier**

quay wall. Ordinary filling was deposited behind the quay wall up to the level of +3·00ft and above that level selected filling was placed in layers and consolidated. The 6in macadam surfacing to the quay was laid upon rolled 9in rubble stone bottoming to a slope of 1 in 60, rising from a cope level of +9·00ft above L.W.O.S.T. All quays have a rubble scour apron screeded at 6in below the dredged level in the foundations of the quay wall and 1,806,000 cubic yards of filling were deposited behind the quay wall. The completed Queen Elizabeth quay is shown in Fig. 6, with sheds under erection in the Delft pier also shown.

*Berths Provided in Colombo Port Development Works*

| Description | Berths | Length in feet | Depth alongside | Transit sheds | Warehouse | Square feet storage |
|---|---|---|---|---|---|---|
| | | | Feet | | | |
| Prince Vijaya Quay ... ... ... ... | 2 | 1,232·5 | 32 | 2 | 1 | 132,000 |
| Oil dock, North Pier ... ... ... ... | 1 | 1,278 | 36 | — | — | — |
| Oil dock, South Quay ... ... ... ... | 1 | 950 | 36 | — | — | — |
| Guide Pier extension ... ... ... ... | 1 | 400 | 33 | — | — | — |
| Delft Pier East Quay ... ... ... ... | 2 | 1,384·5 | 33 | 2 | — | 224,400 |
| Delft Pier West Quay... ... ... ... | 2 | 1,352·5 | 33 | 2 | — | |
| Delft Pier North Quay ... ... ... ... | 1 | 425·5 | 33 | — | — | |
| Delft Pier widening ... ... ... ... | 1 | 340 | 24 | — | — | — |
| Coaster Berth ... ... ... ... | 1 | 310 | 24 | — | — | — |
| Queen Elizabeth Quay ... ... ... ... | 4 | 3,000 | 36 | 4 | — | 220,000 |
| Fishing Trawler Harbour ... ... ... ... | 1 | 240 | 20 | 1 | — | 30,000 |
| | 17 | 10,913 | — | 11 | 1 | 606,400 |

of the berth. A typical construction of this kind is illustrated in Fig. 2, which shows sections of the Delft pier, and Fig. 4 gives a general view of construction in progress at the Delft pier.

Provisions were made in all commercial quays for oil, water and telephone services for the convenience of shipping, but only at the Prince Vijaya Quay were the oil pipes and valves placed and brought into service: at other quays oil chambers were constructed to meet future requirements for bunkering ships.

The sloping blockwork was set at an angle of 67½ deg. to the horizontal, using a "Fidler" Lewis Belt equipment. The blocks were designed with male and female grooves, bonded cross-sectionally, leaving each slice free to settle independently of its neighbouring slices.

All abutments and corners were constructed in horizontal blockwork upon mass concrete foundation, and special blocks were cast to form the commencement of the sloping blockwork at the correct angle.

It was the original intention of the contractors to use floating cranes for block-setting, but it soon became apparent that such a method was too slow, particularly during monsoon periods. The contractors then provided diesel-electric "Titan" cranes, which travelled upon the completed blockwork, to set the underwater blocks; one of them is shown at work in Fig. 3.

The berth dredging did not form part of the original contract, the contractors being required to carry out the foundation dredging which was done by floating grabs. These foundations were carried down to suitable material, determined by the resident engineer, when rubble was dumped and finally screeded to the correct levels by divers using a blinding of 2in broken stone.

The bottom blocks were set upon this screeded bed: after checking for line and level, further blocks were set up to "A" course with a top level of about 3·00ft above L.W.O.S.T. The filling was deposited behind the quay wall to the level of +3·00ft and, excepting in the case of the Prince Vijaya Quay, where the filling was obtained from a land excavation, all filling consisted of pumped dredgings supplied by a suction cutter dredger.

It was only after a period had been allowed for settlement in the quay wall and consolidation of the filling that the construction of the ashlar-faced superstructure was commenced. The selected filling was deposited in layers and consolidated at a later date, after the superstructure had been built.

To expedite the construction of the landward end of the Queen Elizabeth Quay a section of the quay was constructed in mass concrete, inside a cofferdam. The cofferdam was made of steel sheet piling and, owing to meeting boulder formations, the driving of the piles gave rise to considerable difficulties, so much so that the anticipated advantages of this method of construction were not fully realised.

To complete the whole work about 295,150 cubic yards of blockwork were set under water, amounting to some 41,000 blocks, approximately 62,600 cubic yards of rubble were placed

### Quarry and Blockyards

In order to obtain the rubble and crushed stone, the contractors took over and operated a Government quarry at Mahara, situated a few miles out of Colombo. Early in the contract they erected a small crushing plant to provide small quantities of stone for temporary works until the main plant was ready; the output of this was about 90 cubic yards per day.

The main crushing plant was electrically operated and had an estimated output of crushed stone of 100 cubic yards per hour. Actually the total output of the quarry, including large rubble for the quay wall foundations, quay and shed bottoming banks, amounted to about 1200 tons per day of ten hours. The stone was conveyed to the site of the works by rail, special trains being allocated to the contractors by the Ceylon Government Railways, and the graded crushed stone went direct to the two blockyards at Mutwal.

An existing blockyard, near to the old Mutwal quarry, was handed over to the contractors early in the work and was converted by them into an ashlar and pile yard; the main blockyard for the casting of the large blocks, weighing from 4 tons to 20 tons, was constructed on the area near the oil dock.

This blockyard had two "panels," each with two 20-ton and three 5-ton Goliath cranes; all cranes could be moved from one panel to the other by four bogies operating hydraulic lifting jacks. All Goliaths were electrically-operated and fed from overhead wires, whilst the whole blockyard area was fully illuminated for night work.

The blockyard floor consists of a concrete base 12in in thickness, set upon a rubble foundation 700ft long by 300ft. The crane beams were of reinforced concrete, and the concrete mixers were served with aggregate by an endless belt in a reinforced concrete underground tunnel running parallel to the bins of crushed stone and sand. The cement travelled in bulk by belt conveyor from the cement store to the mixers.

The blockyard concrete mixing plant was electrically operated and controlled. The cement and aggregate were delivered into bins above the mixers and, after weighing, passed into the mixers; water was added according to the setting of the gauge. All the gauges were set according to the resident engineer's instructions and sealed by the inspector of works.

The output of the mixer plant was expected to be 40 cubic metres (52·32 cubic yards) per hour, or an average six blocks, giving a daily output of seventy-two blocks in a twelve-hours day. The actual average figures fell somewhat short of expectations, the mixer output being 35 cubic metres (45·79 cubic yards) per hour, i.e. about five blocks, or forty blocks in an eight-hours day. Taking into account weather and holiday losses, a working month of twenty-five days gave an output of the order of 800 blocks, which was considered reasonable.

The concrete was handled in bottom door skips by the 5-ton Goliath cranes and transported by motor lorries. After stripping the blocks were matured with longitudinal water sprinklers as far as possible, but in isolated places the contractors used individual sprays. All block-moulds were constructed of steel set, and on the block floor, and were fitted with standard Lewis bolt recesses. The blocks were stripped and moulds reset during the night generally. The blocks were loaded as required on to block bogies and transported by rail to the block loading jetty and so by barge to the site of the work, to be set in position by the diesel-electric Titans or floating cranes.

### Progress of the Work

Work started at the Prince Vijaya Quay after the berth dredging had been carried down to −32ft by the Colombo Port Commission dredger. The Commission had made and stored some 2000 blocks before the contract was awarded. The block setting commenced from an abutment of horizontal blockwork at the landward end and the construction of the quay offered no particular difficulties; all blocks on this quay were set by floating cranes. The quay was sited at the old oil fuelling jetties, and as these jetties were not demolished the depositing and consolidation of the filling was made more difficult, so much so that upon the adoption of the scheme to use the quay for commercial purposes, previously referred to, it was necessary to carry the transit sheds and office block,

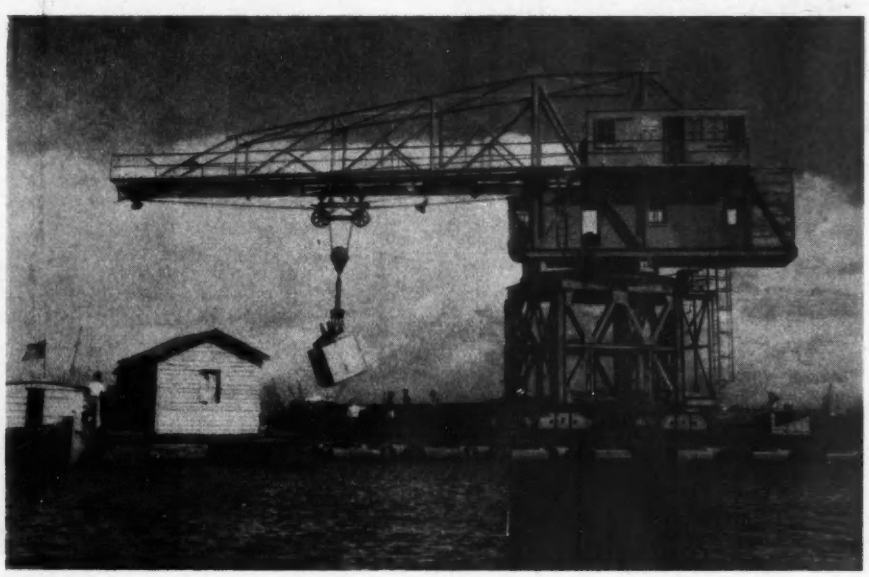


**Fig. 3—"Titan" crane at work setting inclined blocks at the Queen Elizabeth Quay**

# CONSTRUCTION OF DEEP WATER BERTHS AT COLOMBO HARBOUR

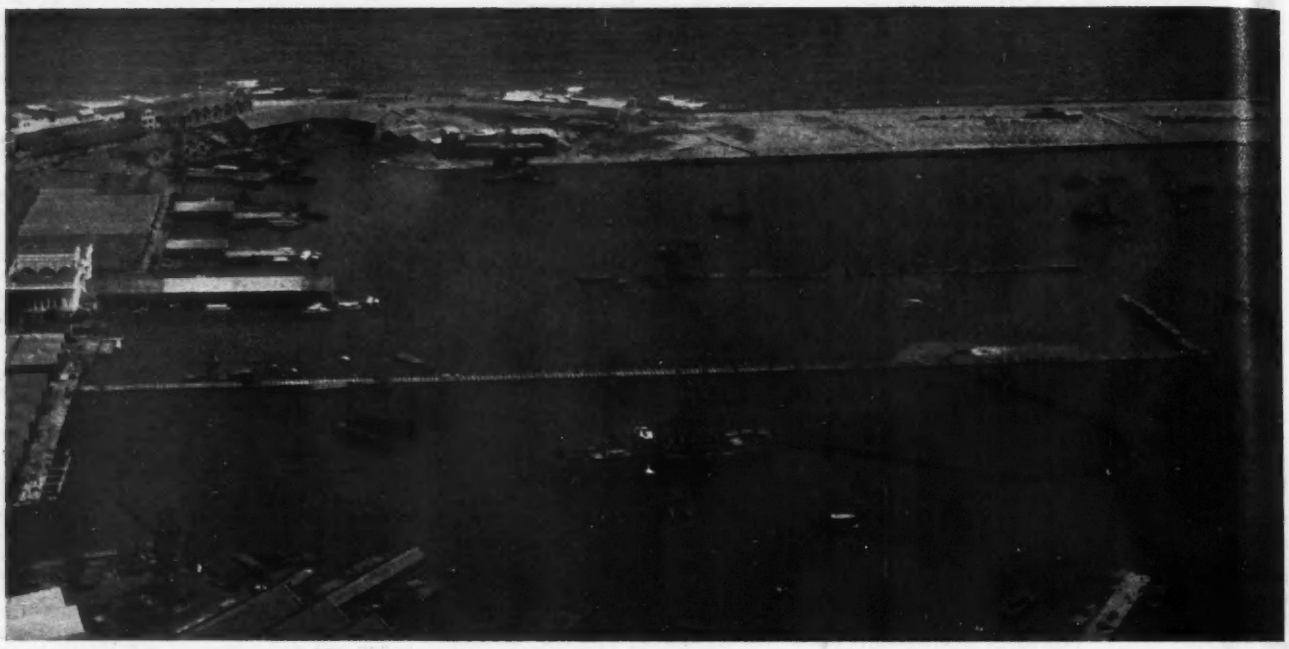


Fig. 4—Construction of the Delft Pier in progress. The dredger is depositing inside the area enclosed by the new blockwork walls, and a blocksetting crane is at work on the West Quay wall. In the background is the newly-constructed quay wall of the Queen Elizabeth Quay

Fig. 5—Colombo harbour. The fishery trawler harbour is in the foreground. Immediately behind it is the Prince Vijaya Quay and the oil dock. The Delft Pier and Queen Elizabeth Quay may be seen in the background

between the sheds, upon precast pile foundations.

The two transit sheds are each 400ft long with a clear span of 90ft, and the floors continue the 1 in 60 inclination from the cope at +9·00ft to form a loading platform at the back of the sheds. The sheds were of structural steel with asbestos roof and sides, sliding doors, and asbestos "Everite" ventilators. The floors were of bituminous asphalt laid upon 9in rubble bottoming and open surface drains with "Lionweld" gratings were constructed cross-sectionally in the floors. The office block was constructed in the 150ft gap between the sheds and elevated to allow two lanes of traffic to pass underneath.

An area of about 12 acres was excavated to harbour level to form the approaches to the quay, and the material used in the filling behind the quay and at the South Quay of the oil dock.

Railway sidings connecting with the quay and a weighbridge were constructed on the levelled area and a new warehouse, 300ft by 200ft, was erected at the root of the quay.

Before the completion of the N.E. Breakwater Quay work commenced upon the North Pier of the oil dock, but owing to the delay in the removal of rock in the foundations the contractors decided to commence blocksetting the horizontal courses at the outward corners of the Delft Pier.

Fig. 6—Queen Elizabeth Quay and Delft Pier. The four transit sheds on the Queen Elizabeth Quay are each 500ft long with a clear span of 110ft. The four transit sheds on the Delft Pier are of approximately the same size; two of them are shown under construction

When stage II (the construction of the Queen Elizabeth Quay) had been given priority over stage I it was decided to commence the blocksetting of this quay and a start was made at about the middle of the quay, where least dredging was necessary, with an "apex" or double abutment of horizontal blockwork laid upon a mass concrete foundation from which the setting of the sloping blockwork proceeded in two directions simultaneously.

In the contract the responsibility for the berth dredging rested with the Port Commission, but as their dredger was out of commission the contractors undertook to do the berth dredging for the Delft Pier and Queen Elizabeth Quay with their cutter suction dredger, which they had provided to dredge and deposit the filling behind the quay walls. The contractor's dredger commenced work in April, 1953, and altogether dredged 708,360 cubic yards inside the harbour, which, with the material dredged from sites along the coast north of Colombo, provided the 1,641,390 cubic yards of filling required.

The filling in the Delft Pier and the Queen Elizabeth Quay was pumped in by the suction dredger and, being almost pure sand, consolidated very readily. In the case of the Queen Elizabeth Quay the mud on the sea bed offered but little difficulty, as it was not present in any major quantity and as the filling commenced about the middle of the length of the quay it was readily sluiced away.

The depositing of the filling at the Delft Pier offered a more complex problem. Generally the filling could only commence after the completion of the blockwork and gaps had to be left in the blockwork to "C" course to allow launches access to the passenger jetty. To meet these conditions the filling commenced from the deep water end working shoreward and every effort was made to sluice away the mud or to confine it to one area.

It was expected that the two sheds at the West Quay would have to be carried on piled foundations, but ground tests showed that the final consolidation was better than anticipated and "Colcrete" piling was only necessary for one transit shed. All the transit shed floors carry the quay apron inclination of 1 in 60 through to the loading platforms at the back of the sheds, and the floors, like the quays, are asphalt surfaces laid upon rubble bottoming, crane rails and railway tracks being recessed to offer a smooth surface for cargo handling trucks and lorries.

The transit sheds and warehouse at the Prince Vijaya Quay were of Continental manufacture, whilst the transit sheds at the Delft Pier and Queen Elizabeth Quay were of British manufacture. Excepting in the cases of the transit sheds at the Prince Vijaya Quay and one shed at the Delft Pier, all the transit sheds and the warehouse are carried upon spread foundations with an allowable loading of 1 ton per square foot. The roofs of the transit sheds have sections of patent glazing, and at the Delft Pier and Queen Elizabeth Quay the transit sheds were fitted with Robertson's ridge ventilators.

As mentioned earlier, owing to its relatively isolated position, an office block was included in the design at the Prince Vijaya Quay, but such elaborate accommodation was not necessary at the other quays. Offices were, however, provided in the end bays in the transit sheds.

All quays have modern facilities for the labour employed handling cargo in the sheds and on the quays.

Excepting at the launch landing steps the contract did not include quay fendering, although fender hangers were fixed in the coping at specified intervals with the exception of the Prince Vijaya Quay. In the case of the Prince Vijaya Quay the Port Commission had made provision to supply 10in Goodyear rubber fenders to be suspended below the coping from special hangers set in the ashlar. At a later date it was decided to fender the remainder of the quays with 16in Goodyear rubber fenders to the extent of a 50 per cent coverage, the fenders being fixed to the hangers set in the coping.

The fishing trawler harbour did not form part of the original contract, but was added at a later date as the Ceylon Government's contribution to the Canadian Colombo plan project. As no suitable site inside the Colombo Harbour was available, the consulting engineers selected a site outside and to the north of the harbour. The scheme included rubble moles, to afford safe navigation during the monsoon periods, the construction of which commenced in 1954. The trawler quay inside the harbour is 240ft in length, with a depth of 20ft alongside at L.W.O.S.T., and is built of sloping blockwork construction with a mass concrete superstructure with precast ashlar facing similar to the main quays. As the moles would have to withstand the full force of the monsoons, heavy rubble was used in their construction and about 90,000 cubic yards of granite rubble were required to complete these and the retaining bank.

Although the construction of the cold storage and icemaking building was under the authority of the Canadian Colombo plan arrangements, the foundations for the buildings were designed by the consulting engineers and carried out under their supervision. Owing to rocky outcrops a number of the foundations are upon pillars carried down to the rock; otherwise the foundations are of bored piles constructed by the Cementation Company, Ltd.

The estimated cost of the development works at Colombo, excluding ancillary items, is in the region of Rs. 95,900,000.

## Book of Reference

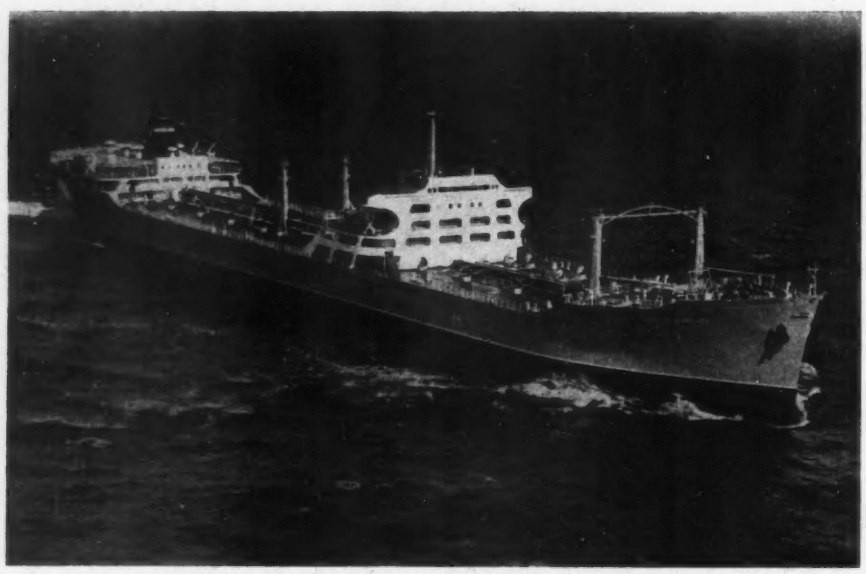
*The New American Machinist's Handbook*. Edited by R. Le Grand. London: McGraw Hill Publishing Company, Ltd., 95, Farringdon Street, E.C.4. Price 67s. 6d.—This is a completely re-written and revised successor to the long familiar *American Machinists Handbook*, the last edition of which was published in 1945. It is designed to provide a complete and concise work of reference for machinists, designers and all others concerned with metal-working methods, material and equipment. The contents are divided into eleven main parts, covering machining methods, metal forming methods, assembling methods, materials, finishing of metals, inspection, fastening devices, tool engineering and drafting practice, machine tool standards, power transmission equipment, and mathematics and tables. Each particular subject is dealt with in a clear, concise way, and in most cases the plentiful use of tables and drawings has enabled the maximum amount of essential information to be presented in a condensed form. A comprehensive index enhances the value of the handbook and enables users to find quickly and easily the information or data they require.

NAVAL STRIKE AIRCRAFT.—Performance and armament particulars are now available for the Westland "Wyvern" strike and fighter aircraft. The "Wyvern" first flew in December, 1946, with a Rolls-Royce "Eagle" H-24 piston engine, and in January, 1949, flew with the Rolls-Royce "Clyde" propeller turbine—in each case the first time the engine had been airborne. The Armstrong Siddeley "Python" first flew a "Wyvern" in March, 1949, and all production aircraft used this engine, a single-shaft turbine with contra-rotating propellers. In order to obtain a satisfactory response to the pilot's controls when landing on aircraft carriers, the turbine was modified to run at constant speed, and the pilot given a very rapid control of airscrew pitch. This control system proved unstable in high-speed flight, and it became necessary to incorporate an inertia governor responsive to the acceleration of the engine and not merely to the error in speed. The performance figures for the aircraft are: maximum speed, 333 knots at sea level; continuous cruise, 303 knots at 20,000ft; initial rate of climb, 2350ft per minute; range, 785 miles. The fixed armament is four 20mm cannon, while external stores can include sixteen rockets, a torpedo, or three 1000 lb bombs. The aircraft weighs 15,608 lb empty, 21,200 lb loaded, or 24,500 lb as an overload case. The span is 44ft, or 20ft with wings folded, and the length 42ft.

# Oil Tanker "Spyros Niarchos"

THE oil tanker S.T. "Spyros Niarchos," which was launched in December last year from the Barrow yard of Vickers-Armstrongs (Shipbuilders), Ltd., was handed over last month to her owners, the Neptune Tanker Corporation, upon completion. The ship, seen on trial in the photograph which we reproduce, is claimed to be the largest tanker completed to date and carries a deadweight of 47,750 tons on the following dimensions: length overall, 757ft; length between perpendiculars, 725ft; breadth moulded, 97ft 2in; depth moulded, 52ft; maximum draught, 37ft 9in. A single set of geared turbines developing a service power of 18,000 s.h.p. gives the ship a sea speed of 17 knots at 36ft draught.

Except for two riveted seams in the bottom shell, two seams at the bilge strake, the lower edge of the sheerstrake, the stringer angle and two seams of the upper deck plating, the structure of the ship is all welded. Transverse bulkheads and two longitudinal bulkheads divide the cargo oil space into thirty-three compartments, and the framing follows normal oil tanker practice. No. 6 wing tanks are not fitted to take cargo oil and there is a cofferdam and cargo pump room forward and aft of the cargo tanks. Construction complies with the rules of Lloyd's Register of Shipping and also those of the American Bureau of Shipping.



Oil tanker "Spyros Niarchos" of 47,750 tons deadweight

A suite for the captain is on the captain's bridge and the apartments for the owner, together with spare accommodation, are on the upper bridge deck. Cabins for the deck officers, all of which are single berth, are located on the bridge deck, while the engineer officers have their cabins in the poop deckhouse, the chief engineer having a suite in a house forward on the boat deck. Large single and two-berth cabins in the poop are provided for the crew, together with a recreation room and a comfortable mess.

For handling the oil cargo there are four 1000 tons per hour Drysdale turbine-driven horizontal centrifugal pumps and three 150 tons per hour Carruthers steam-driven vertical stripping pumps. Four cargo lines of 14in O.D. are fitted in the tanks and on deck, and there are two 10in direct-filling connections and a 6in ring main stripping line. Cast iron heating coils are fitted in each tank. All the deck auxiliaries are steam driven and include an Emerson Walker windlass suitable for handling 3⅛in "Tayco" chain cables, two capstans and three 10in by 14in winches of Clarke Chapman's manufacture. Steering is effected by a four-ram electric hydraulic gear by Brown Brothers, Ltd., powered by two 100 h.p. Laurence Scott electric motors. The mechanical ventilation, heating and air conditioning equipment has been the responsibility of the Winsor Engineering Company, Ltd., and the casings and decks are insulated with materials supplied by Newalls Insulation Company, Ltd. For lifesaving purposes aluminium alloy lifeboats are fitted and these are carried under Schat davits.

### Propelling Machinery and Auxiliaries

A set of double reduction geared turbines of Pametrada design form the main propelling machinery and develop in service 18,000 s.h.p. at 101·4 propeller r.p.m. and a maximum of 20,000 s.h.p. at 105 propeller r.p.m. The h.p. ahead turbine is of impulse pattern and the h.p. astern unit, which is carried on an integral extension at the forward end of the h.p. rotor and housed in a separate cast steel casing, consists of a two-row impulse wheel. A two-row Curtis wheel and one single-row wheel form the l.p. astern turbine, which has a separate casing incorporated in the l.p. ahead casing, which houses the ahead turbine of double flow, impulse-reaction design. The articulated gearing, which has a fabricated gearcase, has forged nickel steel pinions, the secondary pinions being hollow to take the quill shafts, while the gear wheels are of built-up design with plates bolted to flanges on the rim and wheel shaft. Mitchell pivoted tunnel bearings carry the solid forged mild steel shafting, which has a diameter of 21⅞in for the intermediate shafting and 25⅝in for the propeller shafting, the propeller being five-bladed, cast by J. Stone and Co., Ltd., in the company's "Novoston" alloy.

The Weir's regenerative condenser is capable of maintaining a vacuum of 28½in at normal service power with a sea temperature of 75 deg. Fah., and this company has also provided various feed water pumps and other auxiliaries. For handling the lubricating oil there are Auto-Klean strainers, Alfa-Laval purifiers and Serck coolers, while Caird and Rayner steam generators and drain coolers are fitted. Pumps for various services have been provided by Drysdale and Co., Ltd., J. H. Carruthers and Co., Ltd., and Thom Lamont and Co., Ltd., and many of the pumps are powered by Laurence Scott motors.

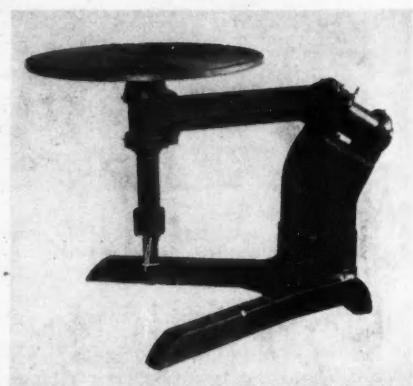
Steam for the turbines is supplied at 600 lb per square inch gauge and 860 deg. Fah. at the superheater outlet by three Foster Wheeler "D" pattern water-tube boilers, which have cast iron gilled economisers, and "Weldex" bled steam air heaters. The boilers burn oil fuel, supplied by a Todd oil-burning installation, under forced draught and are fitted with automatic combustion control equipment, Cockburn's stop and safety valves, and Clyde soot blowers. Axia fans provide the necessary ventilation for engine and boiler-room, and fire precautions in the machinery spaces and the cargo pump room consists of a $CO_2$ extinguishing system provided by W. Kidde and Co., Ltd.

Electrical power for engine and boiler-room auxiliaries and the ship's services is generated by two 850kW Allen self-contained 450V, three-phase, 60 c/s turbo-alternators, capable of running in parallel, but each able to carry the full load. The turbines operate with steam at 570 lb per square inch gauge and 850 deg. Fah. with an exhaust vacuum of 28½in, and run at 6000 r.p.m. driving the alternator at 1800 r.p.m. through gearing. For standby and emergency purposes there is a 150kW alternator driven by a Ruston and Hornsby diesel engine, which automatically starts and supplies power for essential services in the event of a main supply failure. Whipp and Bourne, Ltd., has provided the deadfront main switchboard which is fitted on the generator flat in the engine-room. There is also an emergency switchboard, a main and emergency switchboard fitted amidships to supply the forward part of the ship, and other auxiliary switchboards for local supply.

## Welding Positioner

THE photograph we reproduce below shows a new general purpose welding and assembly positioner which has been developed by Courtburn Positioners, Ltd., Goldington Bury, Bedford, for work weighing up to 1 ton.

On this machine the work is first loaded and clamped on the 36in diameter top plate whilst it is in the horizontal position as illustrated. The central support spindle of the top plate forms the shaft of a screw jack mechanism and the work and top plate assembly is then rotated by hand until the centre of gravity of the workpiece lies on the axis of the main shaft. This brings the work into a balanced position, and the jack mechanism is then disengaged by the withdrawal of a spring-loaded locking pin. The work can then be rotated and tilted to any position freely by hand. When required, spring-loaded plungers can be used to lock both movements, and a friction brake on the tilting arm prevents undue movement of unbalanced loads. The angle at which the tilting arm is set to the main shaft is such that, when the top plate is inverted, any welding positions on the underside of the workpiece are at the correct downhand setting.



1-ton capacity welding positioner

The standard equipment accommodates work from 1 ton at 6in centre of gravity down to about 1 cwt at 31in centre of gravity. The maker states that other models can be supplied to accommodate different ranges of centres of gravity for special production work.

# Opencast Coal Mining in South Wales

DURING the past few years opencast mining has made an important contribution to coal production in this country, and under the programme of the National Coal Board an average of 10,000,000 tons of coal per year will be produced for the next ten years from opencast mines. Last year opencast sites produced no less than 11,400,000 tons of coal, and the Board made a total profit of £4,700,000 on opencast operations. In the early days of this form of mining, both the coal produced and the effects the methods had on the countryside were strongly criticised in many quarters. The criticism with regard to the coal itself was, as has since been proved, quite unmerited, as it is equal in every respect to deep-mined coal, and as a result of strict control in the method of mining generally far cleaner. The restoration of the countryside in the early days did involve new problems and in some cases was not altogether satisfactory. These problems, with the assistance of the Ministry of Agriculture and the Forestry Commission, have now largely been overcome, and it is claimed that in the main restoration is carried out in a satisfactory manner and, indeed, often leads to improvement rather than deterioration of the land.

It is perhaps not generally known that actual mining and restoration in opencast working is not carried out by the National Coal Board itself, but by contractors under strict supervision. The Board determines the site and on the results of its investigations calls for tenders on the basis of price per ton of clean coal delivered, and the opening and restoration of the site. Final payment is not made to a contractor until the restoration work is satisfactorily completed, and throughout the period of working a check is maintained on the quality and cleanliness of the coal delivered.

At opencast sites the operations are very highly mechanised and the output per manshift is higher, whilst the cost of coal production is lower, than in deep mines. It is essentially a civil engineering job and the use of more and better equipment, coupled with increased efficiency gained with experience on the part of the contractors, has resulted in but little change in the cost of opencast coal during the past four years, despite a general increase in prices and wage rates.

Last week the National Coal Board arranged a Press visit to South Wales to show a number of opencast sites in various stages of working, and the standard of restoration at some worked-out sites. Since 1943 some 14,000,000 tons of opencast coal have been won from sixty-one sites in South Wales, and there are at present sixteen sites being worked. These sites are producing about 1,500,000 tons of coal a year.

The first site visited was that of the Tirpentwys group which comprises six adjoining sites being worked by Wilson Lovatt and Sons, Ltd. This site, one of the largest in the country, covers an area of some 648 acres, and is situated on a mountain plateau about 3 miles north-west of Pontypool. The bulk of the area consists of rough mountain pasture with a small amount of arable land, there being about 18in of topsoil and subsoil to be stripped and replaced after the overburden is restored. Under this contract 3,800,000 tons of bituminous coal is being recovered from old mine workings by the removal of some 108 million cubic yards of overburden covering the coal seams at depths up to 153ft. This overburden is mainly sandstone which has to be blasted before it is removed by two 20 cubic yard capacity draglines. Coal from the exposed seams is removed by face shovels and loaded into dump wagons for transport to a central disposal station. At this station the coal is crushed and screened and delivered by a gravity chute down the mountainside, where it is loaded into railway wagons for dispatch to power stations. Actual coal production started in November, 1954, and up to the end of April last 328,000 tons had been mined, the planned minimum rate of production being 7500 tons a week.

The next working site visited was that at Maesgwyn Cap, some 1½ miles north of Glynneath. This is an extension of the Maesgwyn site, from which 915,000 tons of coal were recovered between April, 1949, and October, 1955, and which has been taken over by the Forestry Commission for afforestation purposes. The topsoil of this rough mountain pasture land is being stripped and will be replaced. The site will eventually be regraded to conform with the surrounding country, as has already been done on the original adjoining site. Maesgwyn Cap is being worked by George Wimpey and Co., Ltd., and covers an area of 66 acres. Some 1,018,000 tons of coal to be recovered from the 12ft thick seam of anthracite on this site will involve 27,000,000 cubic yards of excavation and working to depths up to 300ft. Work started here in October last year and up till April last 54,000 tons had been recovered, the minimum expected output being 3000 tons a week.

The overburden is being removed by bench working, using a 7 cubic yard dragline to clear the top 60ft, and 6 yard face shovels in conjunction with dump trucks at lower levels to expose the coal. The coal is removed by a 2½ yard face shovel and loaded into 34-ton and 22-ton "Euclid" lorries for delivery to deep mine washeries some miles away at Aberpergwm and Rhas. Some of the washed and graded anthracite is exported and the remainder sold to home markets.

The Carway opencast site, 5 miles north of Llanelly, is being operated by Sir John Jackson, Ltd., and started production in October, 1953. Up to date it has produced 817,429 tons of high-quality anthracite, and the minimum weekly output will be 6000 tons.

The recovery of the proposed 1,153,000 tons of coal will involve the excavation of some 15,000,000 cubic yards of material. This is a low-lying marshy site and it was covered by poor pasture and scrub. The regrading and draining which will result from the opencast work will probably bring about a considerable improvement to the area.

Removal of the top overburden, consisting of about 40ft of boulder clay, is being carried out by motor scrapers, and the remainder of the material by draglines and face shovels. The anthracite is hauled by dumper wagons to a screening and washing plant at Cold Bach disposal point a mile or two away. This plant has a screen capacity of 150 tons an hour and 90 per cent of the screened product is washed and graded in the washery, which is handling coal from deep mines as well as the opencast coal.

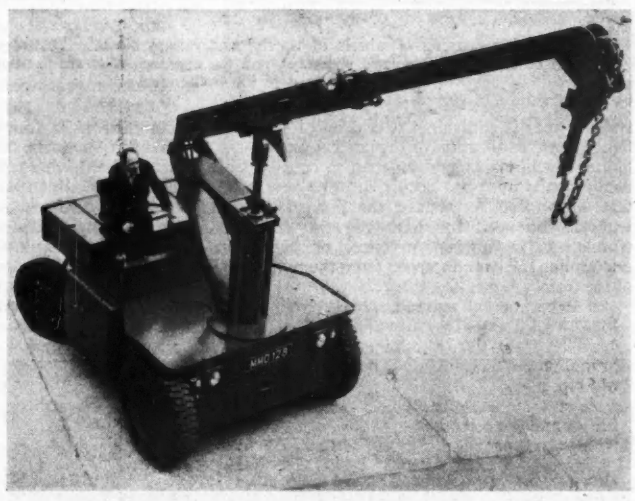
In view of their productive capacity, these opencast mines are worked by relatively few men owing to the high degree of mechanisation. At the Tirpenwys Group, with its weekly production of 7500 tons, only 185 men are employed, including some twenty-five engaged in preparation for delivery to rail. At the Carway site the total production and transport staff for the average weekly output of 6500 tons is ninety-three men, including maintenance workers and night shift.

In the course of the tour some restored opencast sites were inspected, including the Rhigos Pandy and Ffyndaff zone, some 2½ miles from Glynneath. The 90-acre Rhigos Pandy site was worked from February, 1946, until February, 1949, and its restoration was completed in 1951, after 665,000 tons of coal had been recovered by Sir Robert McAlpine and Sons, Ltd. The original surface comprised rough mountain pasture and no topsoil existed. As restored the area is covered by level grass-covered fields which are well drained and served by a good road. The same applies in the restored sites at Kenfig, Cefn and Park Farm worked between October, 1949, and March, 1953, by Wilson Lovatt and Sons, Ltd. In this area some 376,000 tons of high volatile bituminous coal were obtained from land covered with poor grazing and swampy low-lying areas. The original topsoil was replaced and seeded with grass specially selected to suit the land, and the general conditions have been vastly improved. It was quite evident from the restored sites visited that, if they are typical of others throughout the country, opencast mining, rather than being detrimental, might well be ultimately beneficial where the land concerned was originally of a poor nature.

## Mobile Hydraulic Crane

A HYDRAULICALLY operated mobile crane, which is now being made by the British Hoist and Crane Company, Ltd., Compton, Berkshire, is shown in the accompanying illustration. The crane is mounted on a heavy welded steel chassis arranged for rear wheel steering and fitted with a 37 b.h.p. petrol or a 30 b.h.p. diesel engine. Power is transmitted through a four-speed gearbox directly coupled to a differential which drives the front wheels through roller chains.

The crane is mounted on a rigid column at the front of the chassis, and it can be rotated through 175 deg. by a double-acting hydraulic cylinder. The piston-rod of a hydraulic cylinder situated in the main column is coupled to the main section of the jib for raising and lowering purposes. The main jib and its telescopic section are built up of welded rolled steel channels and the extension is moved in and out over a length of 6ft by a double-acting hydraulic cylinder.



Mobile hydraulic crane with a telescopic jib and rear wheel steering

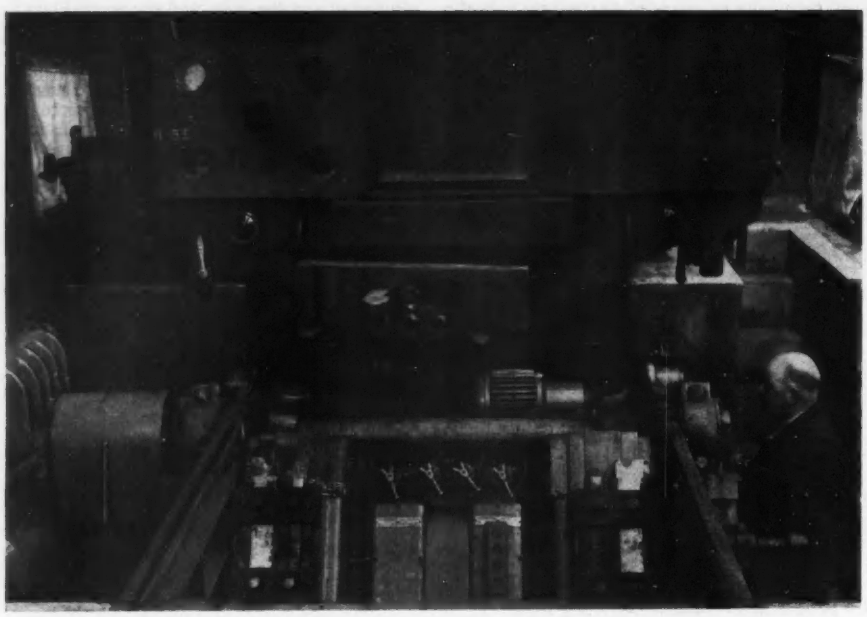
With the jib fully retracted the crane has a capacity over the front of 2 tons at 6ft 6in radius to about 2½ tons at 3ft 6in radius. When the jib is fully extended the capacity is 1 ton at 12ft 6in radius and just under 2 tons at 7ft radius when the maximum lifting height is some 18ft 6in above ground level.

The motions are controlled by three small hand levers and the speeds of slewing, raising, lowering and jib extension are proportional to the engine speed. A hydraulic pressure gauge in the operating system also serves to indicate the load on the hook.

# Lathe for Restoring Wheel Profiles on Underground Trains

CONSIDERABLE savings in maintenance costs and time out of service are now being achieved by London Transport by the use of a new lathe which permits the machining of wheels *in situ* on underground train stock. In sending particulars of this equipment, London Transport states that it was found that on rolling stock fitted with non-metallic brake blocks or inserts, wheel wear was generally confined to the treads, the flanges being relatively unaffected. This was installed at Golders Green Depot in 1947 gave encouraging results and experience gained with it was used to develop the design of a new, and improved, machine. This machine, supplied by the Scottish Machine Tool Corporation, is now in regular use at London Transport's Neasden Depot, and it can be seen in the photographs we reproduce.

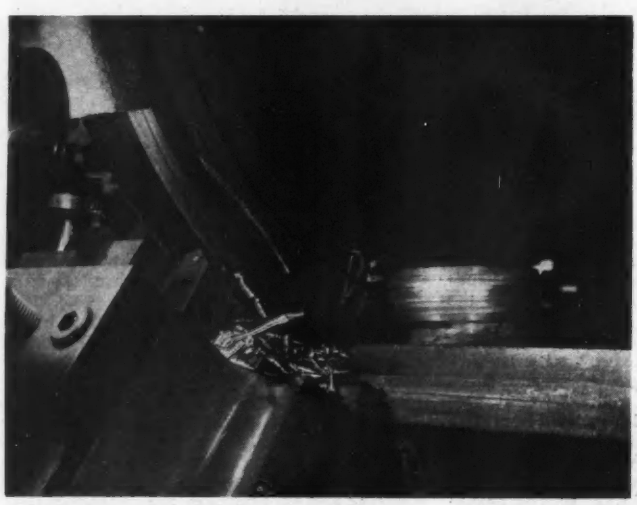
The lathe is situated below rail level on one of the inspection roads, in such a position as to accommodate a four-car train unit on either side of it, and the train is positioned on the wheel lathe driving rollers by the use of a pneumatic cable winch at the side of the track. The wheels are set on the driving rollers of a roller bearing mounted main shaft driven by a constant speed 20 h.p. motor through a "V"-belt drive and worm reduction unit. For turning purposes the adhesion between the wheels and the driving rollers due to car axle loading is sufficient to transmit cutting torque without slip.



Lathe for in-situ turning of wheels of underground railway stock. The two pairs of facing and profiling tools can be seen on the inclined slideways, and the approach rails are in position for receiving the coach in the background

type of wear is equivalent to a deepening of the flanges, and restoration of the correct profile is a lighter machining operation than in cases where heavy flange wear has occurred. The new lathe was introduced to restore the correct profile without the need for removing the defective wheels, as in normal practice, or even for uncoupling the car concerned from the remainder of the train.

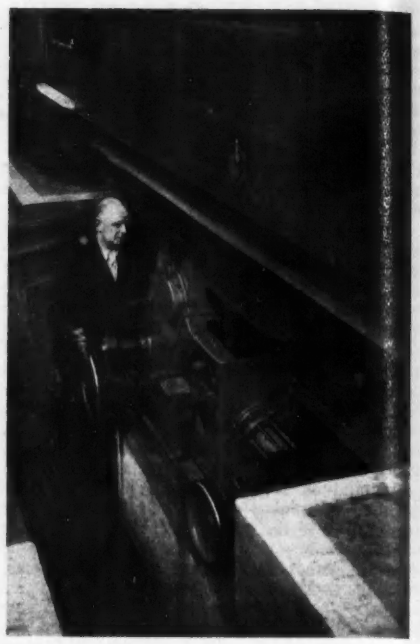
An experimental ground wheel lathe which



Flange being turned on wheel lathe with the lateral thrust roller in operation on the side of the wheel

Retractable steady rollers, which are situated at the rear of the machine to locate the wheels during machining, are hydraulically operated and can be independently adjusted for wheels varying between 28in and 36in diameter. Two thrust rollers, also hydraulically applied, hold the wheels laterally during the machining operation.

After the train wheels have been located on the driving rollers, two hinged sections of approach rails are swung clear to allow the tool-holders to be moved outwards and upwards to their operative positions. Independent quick power traverse, operated through hydraulic clutches, is provided for the longitudinal and transverse movement of each tool slide, and during the cutting operation toolslide feed is applied through large handwheels as shown in one of the illustrations.



Control panel side of lathe with car in wheel turning position and operator at tool slide feed wheel

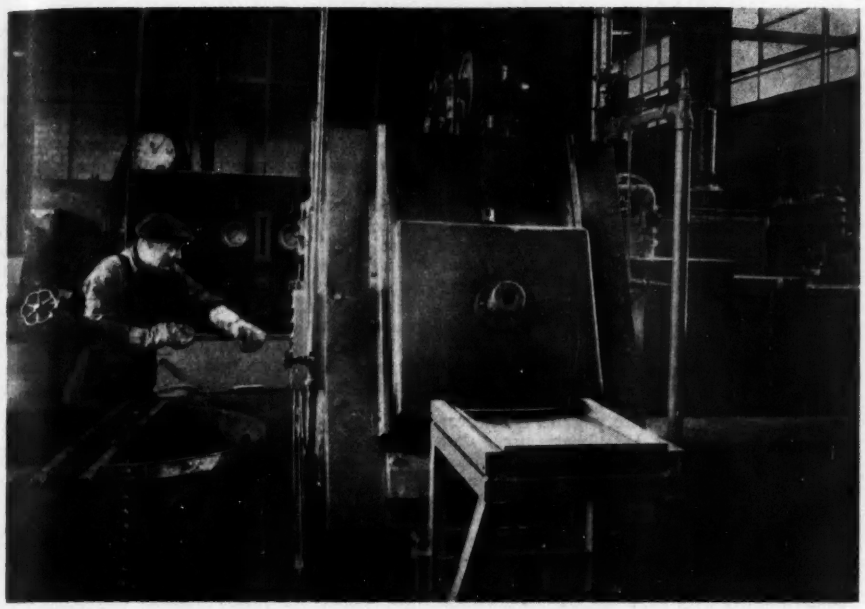
Two tools are used in the machining process, a roughing tool for topping the flange and a profiling tool for restoring the chamfer to the outer edge of the tread and reforming the flange profile. Each tool post carries a pair of these tools so that both operations can be performed as the tool slide is traversed. The cutting speeds are steplessly variable between 13ft and 34ft per minute and they can be changed whilst the machine is in operation by altering the variable drive ratio.

Hydraulic power for operating the clutches and rollers is supplied from a motor-driven pump which is interlocked with the main drive motor to ensure that power is available before the machine is started. The electric control gear, which was supplied by the Igranic Electric Company, Ltd., is contained in a pillar starter in the machine pit ; it embodies a main isolating switch, automatic starting and overload equipment for the main motor, quick traverse motor and pump motor. All the motors are remotely controlled from a push-button panel mounted on the front of the lathe, adjacent to the clutch controls.

## Electrification to Chelmsford

THROUGH electric train services between Liverpool Street Station, London, and Ingatestone and Chelmsford came into operation on Monday last, June 11th. The 20 additional miles of track now to be worked with electric traction represent an extension of the Liverpool Street-Shenfield electrification opened on September 26, 1949. Main line steam services will be maintained to Chelmsford until electrification of the main line is projected beyond that point and steam train timings will in some cases be improved. The electrification operates on the 1500V d.c. overhead system, although provision has been made to convert it later to the new high-voltage a.c. system in accordance with the British Railways national scheme for electrification on the 25,000V, 50 c/s, a.c. system. Also as from last Monday, certain steam services between Chelmsford, Colchester, Ipswich and Norwich were replaced by new diesel trains.

The work of electrifying the section between Shenfield and Chelmsford began in the spring of 1955. Electrical energy at 33,000V, three-phase, 50 c/s is supplied directly by the Eastern Electricity Board to Hylands substation, situated



Operator pushing a tray of work from the pre-heat to the high-temperature section of the furnace for hardening high-speed steel tools

about 7 miles from Shenfield. Hylands is the only substation and has a single 2000kW mercury arc rectifier. The equipment comprises one 500MVA single bus-bar metalclad switchboard having one 400A rectifier breaker and duplicate 30kVA plug-in type auxiliary transformers for substation auxiliaries and signal supplies. The 1500V d.c. switchboard comprises one 2000A high-speed circuit breaker and four 1600A d.c. high-speed circuit breakers. A track sectioning cabin with four supervisorily controlled high-speed circuit breakers is situated at Ingatestone, approximately midway between the existing Shenfield substation and the new Hylands substation. Both the substation and the track sectioning cabin are supervisorily controlled from the existing control centre of the Liverpool Street-Shenfield lines at Chadwell Heath. A pilot cable for the remote control of the substation and the track sectioning cabin is carried in concrete troughing along the lineside in conjunction with the signal and telecommunication cables. The supply for signalling is given from either of the two auxiliary transformers at Hylands substation under normal conditions. A standby diesel generator set is also provided, which operates automatically on failure of the normal supply to preserve continuity of power for signalling circuits.

The overhead line equipment on the Shenfield-Chelmsford extension is broadly the same as that used on the Liverpool Street-Shenfield electrification ; the main and auxiliary catenaries are of hard-drawn copper and the contact wire is of a cadmium-copper alloy. The chief variations are that the total copper equivalent on the extension to Chelmsford is 0·6 square inch per track, against 0·75 square inch and also that span wire registration has been adopted instead of mechanically independent registration. The insulators used are of the cap and pin type. Overlap spans are provided at convenient points along the line which is thus sectioned electrically not only at the substation and track sectioning cabin, but also by hand-operated switches at certain strategically placed overlap spans. D.c. feeder cables from the substation and track sectioning cabin are laid in concrete troughing at surface level to their respective switches mounted on the structures.

Colour light signalling operated by d.c. electric power was installed between Shenfield and Chelmsford in 1937, but the use of 1500V d.c. power for traction necessitated the conversion of the signalling equipment to 110V a.c., 50 c/s operation.

In addition to reconstruction work, considerable pre-electrification maintenance had to be carried out. All cuttings and embankments on the route were strengthened. The track was re-aligned for high-speed running.

## Hardening High-Speed Steel

A FURNACE for hardening precision high-speed steel tools made by the Electric Resistance Furnace Company, Ltd., 161, Queen's Road, Weybridge, Surrey, is illustrated on this page. In this " L " type furnace the preheating chamber is built at right angles to the high-temperature section, which is directly followed by a section where the work is quenched by forced convection in a cooled, protective atmosphere. In this atmosphere quench sections of high-speed steel up to 2½in can be fully hardened.

These furnaces are made in several sizes, but that which has been found very suitable for the average toolroom utilises a 9in by 14in tray with a working height of 10in. The rated output is 90 lb to 120 lb per hour, and the total atmosphere requirements are approximately 400 cubic feet per hour. The atmosphere recommended is endothermic atmosphere operating on town gas.

The preheating zone is filled with metallic elements, and non-metallic elements are filled in the high-temperature section. In each zone the temperature is separately and automatically controlled, and in the final chamber of the furnace the work is cooled to below 200 deg. Cent., so that it will not discolour when removed.

In operation a tray of tools is placed in the vestibule of the preheat zone just inside the charging door. At the end of the required period, depending on the size of work being treated, the operator, using a built-in pusher rod, pushes a tray of work from the high heat zone into the quenching zone, after opening the intermediate door between the sections. The operator then opens the charge door and the last tray is pushed to the transfer section directly in line with the high heat zone. Another tray is then pushed into the preheat zone, pushing all trays one stage forward. The front door having been closed, the operator goes to the pusher station, charges the preheated tray into the high heat zone, and then removes a tray from the quench chamber.

## Adaptable Tubes

A WIDE variety of applications have been found for tubes made of " Nu-Glas " by Ogden Smiths and Hussey, Ltd., Dingwall Road, Croydon, Surrey. These were originally manufactured for fishing rods, demanding tapered sections, and emphasising resilience, a controlled distribution of flexure, freedom from distortion, low moisture absorption, and light weight. These qualities, allied with high dielectric properties, have led to a number of industrial uses, principally for constant section tubing. Single lengths up to 4ft can be produced, and have been used for " whip " aerials, with a copper wire in the tube. It is possible to incorporate an enlarged section at the end of a length, so that the opposite end of a similar tube fits inside it in the manner of a ferruled joint.

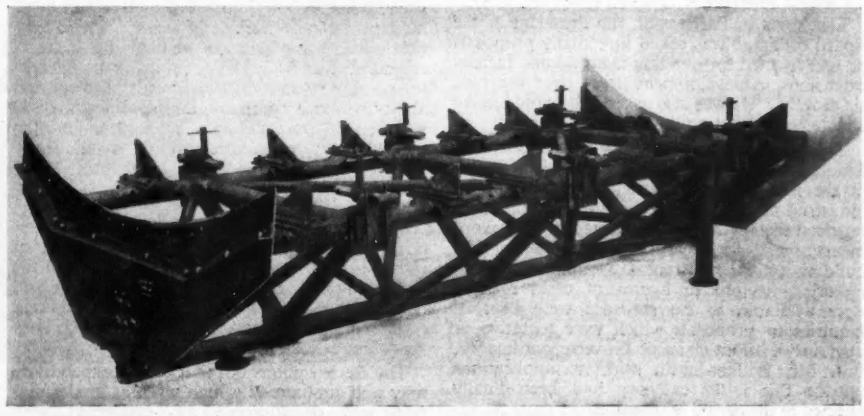
Straight poles are used for fuse changing and other operations on live overhead lines, but where required for insulating ducts or structural members tubes curved round a circular arc can be produced ; their lightness has commended them for aircraft. Permanent joints can be made with appropriate resins, either by bandaging with woven glass fabric, or by making a putty with chopped glass strands and kaolin. This facility of uniting parts rigidly has been exploited by sawing tubes spirally, so that they can be bent to any required contour and then rendered solid with putty or sheaths of glass cloth resin impregnated.

A low coefficient of expansion is claimed, and thus these tubes can be used to make jigs and checking fixtures of great dimensional stability. By using a process of electro-deposition on copper applied with a Schori gun, a skin of chromium can be formed on toleranced locations, so that the accuracy cannot be affected by wear or ill-treatment of the jig. Jigs such as these, besides being rapidly prepared, can often be light enough to be offered up to a job by hand. Tubes for jig bracing can be supplied in two ranges of sizes nesting one within the other : 1⅛in and 1¼in, or 1in and 1⅛in bore.

Three kinds of resin are available : epoxy-phenolic, which allows bores down to ¼in instead of ½in, and offers the quickest processing ; polyester, giving the greatest resistance to high temperatures, and epoxy, in handling which precautions against dermatitis must be observed.

*Tests Taken Over a Range of Samples, at ⅛in Wall Thickness*

| | Epoxy-phenolic | Polyester | Epoxy |
|---|---|---|---|
| Tensile strength, lb/sq. in... ... | 33,000 | 30,000 | 27,000 |
| Coefficient of expansion, per deg. Cent. | $1·0\times10^{-5}$ | $1·2\times10^{-5}$ | $1·3\times10^{-5}$ |
| Young's modulus, lb/sq. in ... | $4·6\times10^{6}$ | $2·5\times10^{6}$ | $2·4\times10^{6}$ |
| Water absorption, per cent ... | 0·1–1 | 0·15–1 | 0·17–1 |
| Electrical breakdown through wall, kV | 12 | 20 | 24 |
| Tracking, kV per in ... ... ... | 10 | 12 | 15 |



This gauge is light enough to be offered by hand into the nose-wheel door opening of the " Viscount "

# Industrial and Labour Notes

### Employment and Unemployment

The latest report by the Ministry of Labour on the employment situation in Great Britain shows that at the end of April the number of people in civil employment was 22,981,000 (15,226,000 men and 7,755,000 women). That denoted an increase of 8000 during the month.

Of those in civil employment in April, 3,976,000 were working in the basic industries, which was 11,000 more than a month earlier. There were seasonal increases in transport and agriculture, and there was an addition of 1000 to the number employed in coal mining, making the total on colliery books at the end of April 706,000. In the manufacturing industries the number at work at the end of April was 9,284,000, or 14,000 less than in the preceding month. The principal decreases were in engineering and metal goods (7000), vehicles (3000), and textiles (5000). Among the changes recorded in other industries and services in April was an addition of 11,000 to the labour force of the building and contracting industries in which at the end of the month there were 1,481,000, compared with 1,464,000 a year earlier.

About unemployment, the Ministry's report says that on May 14th there were 237,431 people registered as out of work, compared with 251,515 on April 16th. The May 14th figure, which represented about 1·1 per cent of the total number of employees, included 29,528 who were temporarily stopped.

### Mineral Working Restrictions

The Federation of British Industries has sent a memorandum to the Ministry of Fuel and Power expressing the view that the nation's mineral wealth is not being fully exploited. This, the F.B.I. says, is because the Act governing the compulsory grant of working facilities is too limited in its application.

The memorandum points out that apart from certain "privileged minerals," such as coal and a number of metalliferous ores and minerals to be found in a few areas secured for mineral working in development plans, only operators having an interest in the minerals may be granted the right to work them. It is considered that this debars many undertakers who have failed to obtain the necessary rights, either by private negotiation or for any of the reasons provided in the Act, from even initiating applications for mineral working.

The Federation urges the Minister of Fuel and Power to amend the law so as to enable any mineral undertaker to apply for the right to exploit minerals which, in the national interest, and subject to planning control, might properly be worked on payment of a fair price or royalty in respect of the right granted. The Federation adds that its experience in matters of procedure has led to the conclusion that the High Court is not the most suitable tribunal for dealing with applications under the Act.

### Factory Building in the Development Areas

Last week in Parliament, the President of the Board of Trade was asked how many proposals he had rejected for building factories and factory extensions in development areas over the past six months. He was also asked if he would make a statement about policy on this matter.

The Parliamentary Secretary to the Board of Trade, Mr. Walker-Smith, who replied, said that, in the last six months, no application for an industrial development certificate for a privately financed factory had been rejected in a development area. As regards applications for the building or extension of Government-financed factories, no precise figures of cases rejected were available, as no statistics were kept of inquiries or proposals which were tentative or obviously without claim on Government finance. But, Mr. Walker-Smith said, no applications outside this latter category had been finally rejected in the period in question.

In view of the need for the strictest economy in Government expenditure, Mr. Walker-Smith continued, it had been necessary to defer consideration of all proposals for the provision of new Government-financed factories or extensions under the Distribution of Industry Act, save in a very few cases of special importance and urgency. The applications which might qualify for that special category were under consideration, and the remainder had been deferred. The latter would be reviewed as soon as economic circumstances permitted.

### Production Problems

In his presidential address, last Saturday, to the Association of Supervisory Staffs, Executives and Technicians, Mr. J. H. Williams urged that both sides of industry should concentrate more on production. If they did not, he said, and continued to argue "about the distribution of the little bit of surplus," they would end up like dogs fighting over a bone with no meat on it. If we went about it the right way, Mr. Williams continued, there could be provided a good standard of living for all, and there could still be a surplus. Never again, he added, must there be seen the sorry spectacle of thousands of men idle, and essential work held up, because the trade unions could not agree on who should drill a small hole.

Mr. Williams went on to say that the problems concerned with automation were not so simple that they could be solved, as some thought, merely by a shorter working week and a bigger pay packet. Such a solution, he asserted, could cause a situation where sections of industry which were readily adapted to automation could be on a twenty-hour week or less, with a pay packet ten times as large as that of workers in other sections of industry which were not so easily adaptable. All concerned must learn that consultation between employers and employees was essential when the initiation of new manufacturing methods was first contemplated, and not after the policy had been decided and the project put in hand. The first requirement, Mr. Williams commented, was a better spirit in industry. All the fine phrases and platitudes in the world, he said, would not produce industrial peace unless the Government took a more positive line to stabilise the position by "exercising control over prices and essential commodities and proving to the workers that they would get a straight deal."

### Management Education

The British Institute of Management has begun a series of seminars in management development and education. These seminars will occupy one day a week until July 5th, and during them a group of senior managers and training officers from various kinds of industry will study and discuss methods of meeting the shortage of managers.

The discussions are aimed at helping those attending to shape plans for their own companies, and at the same time enable them to put forward suggestions for the improvement of schemes of management selection and training. Consideration is also being given to the planning ahead of the number and kind of positions to be filled in the coming years, the development of talent and ability within a company, the identification and selection of potential new managers, and the uses that can be made of training techniques.

### The Conquest of Inflation

The latest issue of the *District Bank Review* contains some comments on the conquest of inflation in this country. It says that since the restraining measures applied by the Government have not yet curbed the "over-exuberant economy" it is not surprising that there has been some loss of faith in the correctives.

The *Review* points out that capital expenditure may well continue at a high level, as modernisation and development are connected with economies in production, as, in general, industry is still liquid and largely independent of bank finance, and as constructional schemes once started cannot easily be brought to a halt. Projects undertaken this year, it is recalled, are the outcome of orders placed many months ago. Since the factory building schemes begun in the first half of 1955 were, under the influence of the 1954 Budget, much more numerous, and the schemes approved recorded an even greater increase, "it is evident that, despite existing restrictions, the peak of industrial constructional work has still to be reached." Here, the *Review* suggests, we get to the very root of our manpower problems. Although Government action has released labour in some directions, the aggregate demand created by capital investment continues to absorb the surplus. Hire purchase and credit restrictions have not prevented the springtime rise in employment, a reduction in short time and an increase in the number of unfilled vacancies. If, therefore, constructional work has yet to reach its climax it seems likely that the shortage of manpower will become even more acute. The effect of such a state of affairs on production, the *Review* observes, will be serious, but even more serious will be the effect on costs, since it would seem that the determination to press wage claims will remain unchanged.

The efficacy of the plans for reducing consumption, cheapening production, and thereby increasing exports, could be undermined, the *Review* continues, and the prospects of narrowing the gap in the balance of payments could recede. But, it is suggested, partial relief should be obtained if the new savings incentives restrain personal spending and thus counter the inflationary effect of rising wages. Then, the heavy importing of last year may provide some of the raw materials required for our oncoming growth of production. It may be, the *Review* adds, that before such relief is exhausted our increased capacity to produce will provide us with much-needed exports, though this outcome would appear likelier if the restraining measures could be made to work more speedily. Whether or not, therefore, "inflation will be conquered seems increasingly to resolve itself into a battle against time."

### A "Railway Revolution"

Last Tuesday, Sir Brian Robertson, chairman of the British Transport Commission, addressed the Tees-side Chamber of Commerce, and spoke about the "major revolution" that was now in process on British Railways. Sir Brian said that when a vast and intricate organisation like British Railways had been deprived of the means to improve or even to maintain itself adequately over a long period of years, it was quite impossible to transform it overnight.

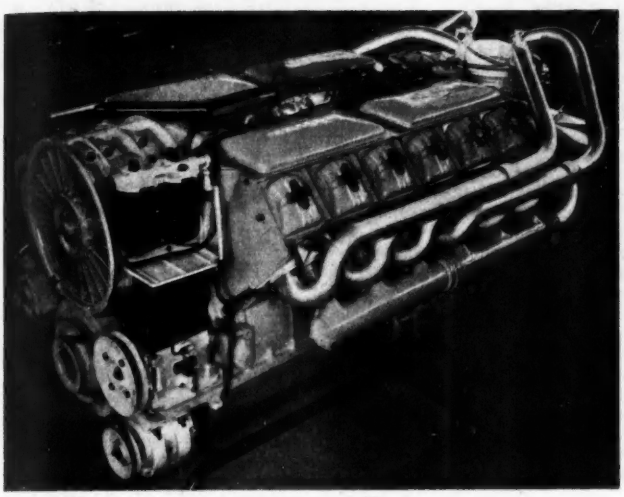
The upheaval now in process, Sir Brian continued, was not only a question of new equipment, or electrification or any other technical improvement. It was a revolution in methods of operation, administration, communications and much else. The strain which that imposed upon the senior management of the railways was very heavy; planning and reorganisation on an immense scale were being done while the service had still to be maintained. Sir Brian mentioned these matters firstly, he said, to emphasise that what was taking place would result in this country having a railway system second to none in the world, and, second, to warn of the unreasonableness of imagining that if management would show a little more intelligence, or if the men would roll up their sleeves a little higher, a dramatic change would take place!

The change would come, Sir Brian added, and it would be dramatic, but it would take some time. It was absolutely conditional upon the steady maintenance by the Government of a policy of support for the railways, including particularly provision for the capital expenditure which was necessary for their modernisation. The amount of capital required and the way in which it was spent were both matters requiring very careful calculation and planning.

# Continental Engineering News

## Supercharged Air-Cooled Diesel Engine.

OUR illustration shows a 250 h.p. air-cooled, supercharged, diesel engine recently introduced by Kloeckner-Humboldt-Deutz A.G., Cologne-Deutz. It is based on an "A12L614" engine with twelve cylinders in vee-arrangement and has an output of 250 h.p. when running at 2000 r.p.m. The axial cooling air blower is seen at the left-hand end of the engine, and is designed to deliver from 1750 up to 2000 cubic feet of air per horsepower-hour to the enclosed ribbed cylinder casings and heads. The engine works on the four-stroke principle with a "Deutz-L. Orange" swirl chamber, and a Bosch fuel pump and injectors. The exhaust gas turbo-blower is mounted over the flywheel at the driving end of the engine, and the vertical drive provides a convenient arrangement for the exhaust pipe and the supercharging pipes which are short and have easy bends. The trials made with this engine are said to show that full power is about 25 per cent higher than the power of the engine without supercharging. This can be developed without undue stress in the principal working parts. The firm is represented in Great Britain by A. Kracko, Ltd., 84, Drewstead Road, London, S.W.16.



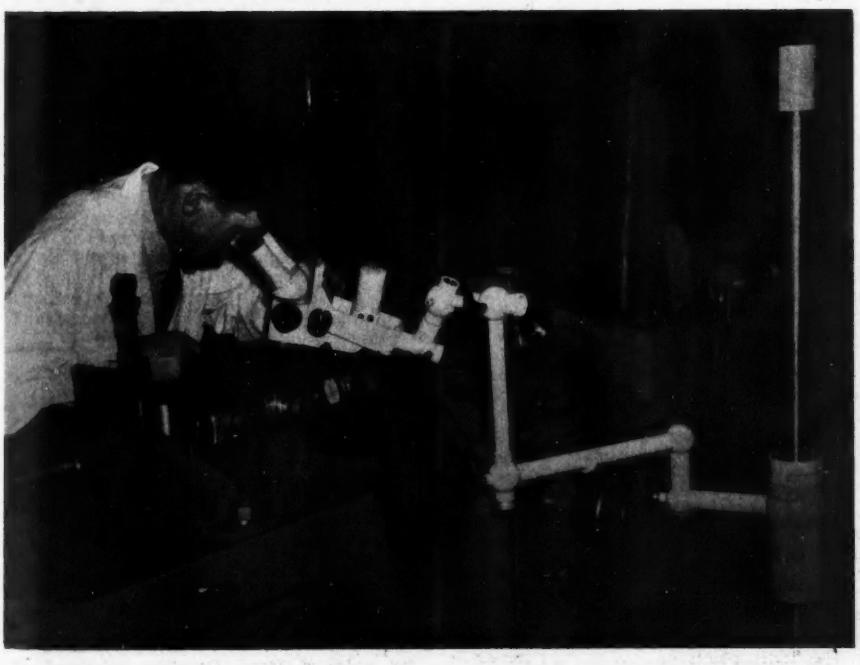
**250 h.p. supercharged, air cooled diesel engine. The cooling fan is on the left, the exhaust turbine blower on the right**

## Technical Binocular Microscope

For the investigation of metallurgical defects, including corrosion and fatigue, the examination of the microstructure of welds and rivets, the identification of foreign bodies in greases and paints, and other technical purposes, the firm of Carl Zeiss, Oberkochen (Württemberg), has put on the market a stereoscopic microscope called the "Technoscope," which we show in the illustration reproduced below.

The instrument is mounted on a portable stand, which can move on rollers, and is arranged so that a photographic camera can be fitted. A variable-intensity light source is built in, as are a number of filters. Five different magnifications from six times to forty times can be obtained by rotating a knurled knob, without having to adjust the working distance. The long focal length permits the examination of bores and channels, and the stand with its multiple universal joints allows the instrument to be used even on parts of completed structures which are accessible only with difficulty. Anything seen through the binocular viewer can be photographed and stereoscopic photographs can be taken if required.

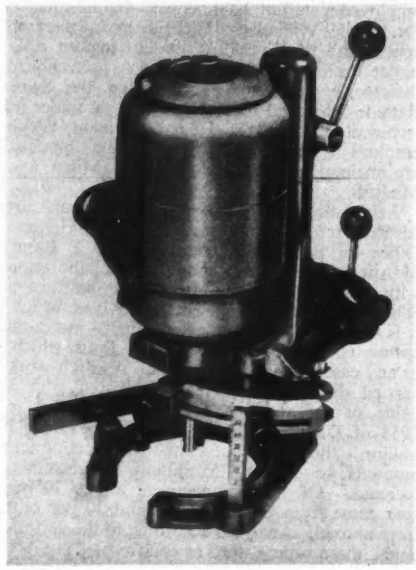
Carl Zeiss is represented in the United Kingdom by Degenhardt and Co., Ltd., 32, Maddox Street, London, W.1.



**The "Techniscope" binocular microscope for viewing or photography is mounted on a universally-jointed rolling stand. Objectives of 125mm and 200mm focal length are available. Magnifications 6x to 40x**

## Portable Router

In the accompanying illustration we show a portable router made by Eugen Lutz K.G., Mühlacker-Lomersheim, German Federal Republic. This machine, the "Model MOF 11e," is made in two versions for 1200W/16,000 r.p.m., and 2000W/18,000 r.p.m., weighing, respectively, 9·5 kg and 11 kg. The router is supported on a single-column stand, giving the operator a good view of the workpiece. A bellows covering the column protects it from dust and reduces wear of this component. The lateral scale, indicating the swivel of the tool, is adjustable so that it can be set for cutters of different diameters. In this way reduction in cutter diameter due to regrinding is compensated. Setting back the head through 180 deg., so that it overhangs the base at the rear, allows the tool to be used on the edges of workpieces. Depth can be adjusted down to a maximum of 60mm, a fine adjustment to the scale being provided.



**Portable router for wood. Maximum depth 60mm, cutter can be tilted up to 30 deg.**

Of particular utility is the fact that the router can be tilted by up to 30 deg. This is of importance, e.g. in the manufacture of staircases. The cooling air is used to blow away the chips so that the field of operation is always clear. The machine is equipped to prevent wireless interference.

## The Lower Saxony Coastal Plan

The ten-year coastal plan for Lower Saxony, which was approved last year by the German Federal Parliament, is concerned with conservation in East Frisland, Oldenburg, the district of Stade, and parts of the district of Lüneburg. It was conceived when, under the impression of the Dutch flood disaster of 1953, a detailed inspection of the coastal districts between the Rivers Ems and Weser was made in the spring of 1954 by the agricultural commission of parliament. Even before then, in fact since 1948, substantial annual sums have been spent by the land of Lower Saxony to which the Federation contributed. These funds have, however, proved adequate only to reinforce the points of greatest danger. The present plan foresees the spending of DM.770 million over ten years. A commissioner has been appointed to supervise its implementation. He will be assisted by an agriculturist and a committee of six experts from the regional water and agricultural associations and the local authorities.

## Annual Report of the Battelle Institute, Frankfurt/Main

The Battelle Institute in Frankfurt-on-Main is one of the most important European centres for sponsored research. Sponsored research is a development which started in the nineteen-twenties in the United States, and has, since the war, advanced rapidly on this side of the Atlantic. We have previously described the Frankfurt establishment in these pages (see THE ENGINEER, September 16, 1955, page 416). The second annual report to be published by Battelle/Frankfurt has now reached us, and the following is based on this report.

At the end of last December, the Battelle Memorial Institute, in Columbus, Ohio, together with its Daytona Beach, Florida, and West Jefferson, Columbus, laboratories, employed a staff of 2200 people. Its president is Dr. Clyde Williams. The European research centres are the Frankfurt Battelle-Institut e.V., under Professor Dr. Max Barnick as technical director, which employs 304, and the Swiss Battelle Memorial Institute at Geneva, under its technical director, Dr. Hugo Thiemann, which employs a staff of 120. In addition, bureaux are maintained in London, Paris, Milan and Madrid.

At the beginning of its report, the Frankfurt Institute refers to the formation of the German Office for Sponsored Research (V.f.V.), Bonn, in April of last year, and to its collaboration with this organisation. Its report indicates a substantial increase of research activities, which, it is stated, is to a large extent due to increased sponsored research on behalf of firms which, in any case, spend large sums on research work carried out by themselves. Compared with a value of the research contracts concluded in 1953 of DM.215,000, and in 1954 of DM.1·1 million, the value of last year's contracts amounts to DM.3·025 million, a substantial increase. Of the orders given, about 70 per cent came from German firms and 30 per cent from abroad. Analysed according to the various fields, these orders were as follows :—

| | Per cent |
|---|---|
| Chemistry | 42 |
| Physics | 18 |
| Mechanical engineering | 14 |
| Silicate technology | 8 |
| Metallurgy | 9 |
| Technical investigations | 6 |
| Market research | 3 |
| | 100 |

If one looks at the firms concerned, one finds the following picture :—

| Number of employees in sponsor firm | Percentage |
|---|---|
| Up to 200 | 19 |
| 200–1000 | 18 |
| Over 1000 | 63 |
| Total | 100 |

Orders from abroad increased. These came from England, France, Greece, the Netherlands, Italy, Austria, Portugal, Sweden, Switzerland, Spain and the U.S.A. The report publishes the names of a number of firms (which can be done only with the written consent of the firm concerned). It quotes an instance where a French and a German firm sought to place contracts covering the same theme. In such cases Battelle can only work for the first applicant, but here the two firms could be persuaded to place a joint contract, thus sharing both the results and the cost.

The most important working principle is considered to be adaptability to new trends in the demand. Industrial inquiries and contracts make it clear that certain further laboratories should be set up. Among these was a building materials laboratory (attached to the department of silicate technology). Here borderline problems are investigated, such as resistance to weathering, sound and heat insulation, and wear resistance of floors, In the field of chemistry, laboratories were opened for organic synthesis, microbiology, surface chemistry, high pressure technology, textiles and paper. The paints laboratory and the department for plastics were substantially enlarged. In the paper laboratory, an experimental paper-making machine for a paper width of 300mm, made by Paschke of Darmstadt, was installed. A radiation laboratory was also established in which investigations can be carried out into preservation, sterilisation, ageing and materials testing. The laboratory has available hard and soft X-rays, ultrasonic vibrations and radioactive isotopes such as cobalt 60.

In the Department of Physics an optical laboratory has been added, and also equipment for measuring dielectric constants and loss angles of solids and liquids with maximum attainable accuracy. The isotope laboratory was completed, making use of the experience of fifteen years which the Institute in Columbus had in this particular field. Considerations of safety rendered it necessary to provide the staff of this section with their own facilities for washing and changing. Special concrete cupboards had to be installed for storing radioactive isotopes, and leaden transport containers had to be provided. In order to enable radioactive contamination readily to be cleared up, the wall and floor coverings are easily removable. A lock leads to the counting room which contains apparatus for measuring the various radiations. The " hot " laboratory, where materials can be irradiated, contains a cobalt-60 source of 1535 Curie, in a water tank 4½m deep.

The engineering section has been enlarged by the addition of an engine-testing laboratory, as well as equipment for carrying out fatigue tests.

Since the volume of present orders is such that existing facilities, intended for about 400 workers, are nearly fully occupied, it has become necessary to push forward plans for further buildings. In the first instance a three-storey building covering a site area of 900 square metres is being erected in continuation of the present main building, and will be ready by this summer. In the basement of this building a " Univac " electronic calculating machine, made by Remington Rand, is to be installed. This will be the first " Univac " centre in Europe. Its services will be available to industry, science and administrative bodies. For further expansion an additional area of 75,000 square metres was made available by the municipality of Frankfurt last October.

As regards the staff, the report states that the membership of 304, mentioned at the beginning of this article, constitutes an increase of nearly 100 during the year, of whom the great majority were highly qualified scientists and engineers. The staff comprises 61 per cent scientists and engineers, 23 per cent assistant technicians, and 16 per cent administrative personnel. The various branches are represented as follows :—

| | Per cent |
|---|---|
| Management | 1 |
| Administration | 16 |
| Construction and operation | 21 |
| Investigations | 14 |
| Chemistry | 18 |
| Physics | 9 |
| Engineering | 7 |
| Metallurgy | 6 |
| Silicate technology | 4 |
| Contracts department | 1 |
| Public relations | 1 |
| Market research | 2 |
| | 100 |

The modern equipment, the variety of problems which are being investigated, and the constant contact between the different branches, naturally render the Institute attractive to young scientists and engineers, so that about 100 inquiries for posts are received each month, of which only about one-fifth are in reply to vacancy notices. From forty years in 1952, the average age of the staff has steadily dropped, due to continued intake of junior members, until it reached thirty-four years at the end of last December.

### Oil Search Under the North Sea

Geologists have started to examine the bottom of the sea along Germany's north coast in a search for oil. Although as yet there is no proof that underwater oil deposits exist, the fact that oil has been struck on land near the coast makes it seem highly probable that these deposits extend seaward, since geological formations are independent of the shore line.

The present investigations are not the first in this region. In 1949 the Deutsche Erdöl A.G., of Heide in Holstein, prospected in the Bay of Dithmar, first with light drilling equipment, later with a drill tower erected on the sandbank of Helmsand. No oil was found, but greater knowledge of the rock strata at depths to 10,000ft made it possible to undertake subsequent successful drilling on the land side of the dyke in what has meanwhile become an extensive oil-field near Heide.

In 1952 the research ship " Gauss " examined nearby coastal waters geophysically. The " Gauss " had in tow floating sounding apparatus for registering the effects of underwater explosions. These experiments showed that there are saline mountain ranges on the sea bottom between the dykes and Heligoland. These are the continuation of similar subterranean strata on the Continent. Experience has shown that oil deposits along the flanks of such mountains are more than likely.

After the war many oil deposits were found in Germany, principally in Oldenburg, Bavaria, and the upper valley of the Rhine. It had not, therefore, become necessary until now to proceed to marine drilling, a far more expensive process than land drilling. In 1955 the German oil resources showed a considerable drop for the first time in decades, so that it became urgent to exploit underwater deposits. Similar plans are in hand in the Netherlands. Both countries will be able to apply to these projects much of what has been learned in the United States, where for some years drilling for oil on the bottom of the sea has been in progress. Off the coasts of Texas, Louisiana and California drilling for oil has been going on in depths of water corresponding to German coastal waters far beyond Heligoland, so that similar techniques should be applicable.

### Scientific Research in Switzerland

In the fourth annual report, covering the year 1955, the Swiss National Fund for Scientific Research states that of 319 requests for support, 177 have been granted, thirty-five refused, two referred to other institutions, and twenty-five were withdrawn by their authors ; eighty applications are still under consideration. For the 177 research schemes which were approved, sums totalling nearly 3,100,000 Swiss francs have been made available. To this amount must be added another 423,000 Swiss francs expended as stipends or subsidies for ninety-six young scientists. Amounts of 100,000 Swiss francs each have been set aside for medical and for legal research.

### German Rural Water Supplies

At the beginning of this year 8400 rural communities in the German Federal Republic remained without piped water supplies. This represents a population of about 8,400,000. Without domestic connections, an investment of DM. 2300 million would be required to provide these people with piped water. An additional D.M. 460 million would be necessary to make these connections. Moreover, an estimated DM. 900 million are required for the extension, improvement and renewal of existing water installations. The German " Green Plan " for agriculture makes provision for loans and credits for improvements in the water supply on the land, to the extent of about DM. 300 million per year. This sum is to be provided by the Federal Government, the Länder and the communities themselves.

### Welding Congress in Hanover

This year's annual congress of the Deutscher Verband für Schweisstechnik e.V. (German Association for Welding Technology) is to take place from June 18th to 20th in the Niedersachsenhalle, Hanover. The congress will have as its theme " The Welding of Tools and Machine Tools for Cutting and Non-Cutting Operations." There will be seven lectures, giving a general survey of the state of welding technology and its applications, as well as dealing with more detailed problems, such as hard surfacing and flame hardening. In addition there will be a report about a study tour in the U.S.S.R. Details may be obtained from Deutscher Verband für Schweisstechnik e.V., Düsseldorf, Harkortstrasse 27.

# Heavy Extrusion Press Plant at Halethorpe, Maryland

No. 1

*The Kaiser Aluminum and Chemical Corporation recently completed, at a cost of* 25,000,000 *dollars, a heavy extrusion press works addition at Halethorpe, Maryland. This factory is now one of the major American heavy aluminium alloy extrusion facilities and was conceived, constructed and financed as part of the heavy press programme of the U.S. Air Force. The plant installed includes two* 8100-*ton extrusion presses, two semi-continuous "D.C." billet casting machines and various ancillary equipment. Together with five older presses and four new presses, to be installed later this year, the Halethorpe works will ultimately have an annual extrusion capacity of about* 70,000,000 *lb.*

THE heavy extrusion press works now being operated by the Kaiser Aluminum and Chemical Corporation on behalf of the U.S. Air Force at Halethorpe, near Baltimore, Maryland, is an excellent example of latest American practice in the field of large aluminium alloy billet casting and heavy press extrusion. The present works occupies a building 730ft long by 440ft wide, and there are separate office and storage buildings. It is situated adjacent to the so-called "light-press" extrusion works which the company has operated for more than five years and recently purchased from the U.S. General Services Administration. The latter works comprises one 4400-ton "Baldwin-Southwark" press, two 2500-ton "Schloemann" presses, one 1600-ton "Schloemann" press and a 500-ton "Watson-Stillman" press used for experimental purposes. With the exception of the last press, which is a self-contained unit, all the other machines are powered from a central pumping station. It is of interest to note that this older installation also uses reverberatory melting furnaces in conjunction with vertical semi-continuous "D.C." billet casting machines, and much of the latest plant now installed in the "heavy press" section is based upon design and operating experience obtained during the last few years in the "light press" section. The latter part of the works comprises three gas-fired single-hearth reverberatory furnaces having a melting capacity of 30,000 lb each. These furnaces are tapped into 5000 lb capacity ladles, which are electrically heated through resistance elements mounted within the ladle lids. Thus metal temperature is maintained while the ladle awaits transfer to the casting station and during fluxing which involves the passage of chlorine gas through the molten metal.

The "light press" section of the works comprises two vertical semi-continuous "D.C." billet casting machines, which can cast billets up to 10ft in length. Hydraulic operation is applied to both the ladle tilting mechanism and the billet descending unit in order to obtain a constant and controlled rate of casting. In addition to the casting machines and the extrusion presses

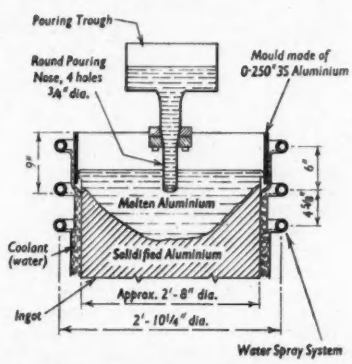



**Fig. 1—Cross-section of representative American "D.C." semi-continuous casting equipment for the production of 32in diameter aluminium alloy ingots**

mentioned above, the "light-press" section comprises several homogenising furnaces, a billet saw, a vertical heat-treating furnace and various stretching, straightening and de-twisting machines.

### Billet Production

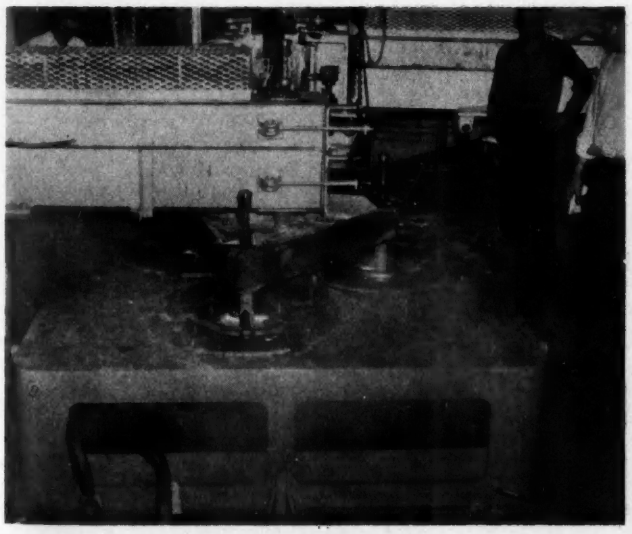
At the "heavy press" section of the Halethorpe extrusion works up to 15,000 lb of aluminium alloy is melted hourly in four gas-fired reverberatory furnaces, which were made by the Dempsey Industrial Furnace Corporation, of Springfield, Massachusetts. The furnaces have a 50,000 lb melting capacity each, and the melting hearths are 10ft by 22·6ft, with an average metal depth of 20½in. The holding hearths are 10ft by 11ft, with an average metal depth of 21½in, and have a holding capacity of 30,000 lb each. The aluminium raw material used at Halethorpe is primarily obtained from the Chalmette reduction works of the Kaiser Company in Louisiana.

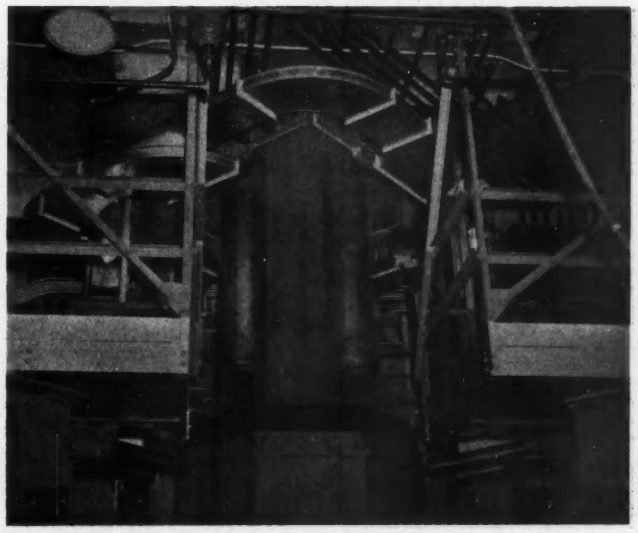
The new works also employs the "direct-chill" or "D.C." process in casting the extrusion billets up to 20in diameter on a semi-continuous basis. In view of the important influence which this process has had on the development of the American aluminium industry since its introduction in 1935 by the Aluminum Company of America, it appears appropriate to review its history here in some detail.

There are to-day two fundamental methods of casting large ingot sizes of the higher-strength aluminium alloys for rolling, forging and extrusion purposes, known in America, respectively, as the "water-dipped" and the "direct-chill" processes. The water-dipped method consists of filling a heated, relatively thin, sheet metal mould with molten aluminium alloy at an optimum temperature, and then lowering the filled mould at a controlled rate through a water spray while supplying heat to the upper or unsolidified portion of the aluminium alloy.

The newer "direct-chill" process consists of introducing molten aluminium alloy, at an optimum temperature, through a pouring spout into an open-end, short, water-cooled, metal mould. The high-conductivity metal mould is closed temporarily at the bottom end by means of a metal bottom block. After solidification of the aluminium alloy first poured into the mould the bottom block and the solidified and solidifying portions of the ingot are lowered vertically through water sprays. The amount of molten metal introduced into the mould is synchronised with the rate of lowering the solidifying aluminium alloy ingot. Progressive bottom-to-top solidification and rapid freezing are obtained in both the water-dipped and direct-chill processes. However, the direct-chill process, as its name implies, provides faster chilling and consequently the more desirable metallurgical structure, such as finer grain and constituent size. The direct-chill process is used to a greater extent than any other casting process in the American aluminium industry because higher quality, higher production rates, and lower costs are obtained.

In the United States to-day the "D.C." process is performed semi-continuously by casting ingots to such considerable lengths as 25ft at Halethorpe. On the other hand, continuous "D.C." ingots are cast in Europe with modified equipment so that the ingot is sawed to length





**Figs. 2 and 3—(Left) Casting station at furnace level of "Loma" semi-continuous "D.C." billet casting machine. (Right) View of "Loma" semi-continuous casting machine below furnace level deck, showing three simultaneously cast billets during descent**

during casting by means of a travelling saw. The less complicated semi-continuous method is preferred in the case of aluminium in the United States for several reasons, the chief one of which is greater flexibility. The semi-continuous method is better suited to the casting of the large high-strength aluminium alloy ingots because of the high internal stresses set up within the ingot during casting, which could cause splitting if sawed prior to stress relieving or preheating.

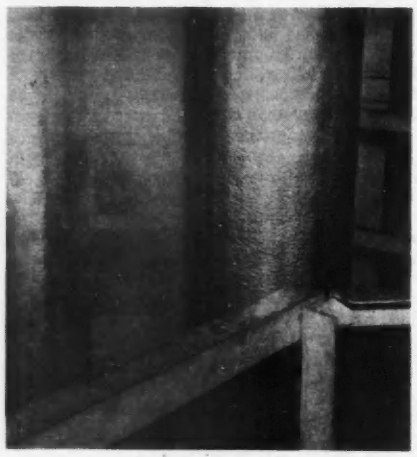


**Fig. 4—View showing the high surface quality of the as-cast billets**

The D.C. equipment generally used in the United States for casting large diameters of aluminium alloy ingot is shown in Fig. 1. This simplified sketch shows the D.C. process to consist of equipment to introduce molten metal at a controlled rate into a water cooled mould and to lower the partially solidified ingot at a controlled rate through direct water sprays. In the arrangement illustrated the mould is 9in in length and is made of ¼in thick 3S aluminium alloy plate welded to a 32in I.D. The top spray water cools the mould while the two lower sprays play directly on the ingot surface. The top of the molten metal is 3in above the bottom edge of the mould and this distance is termed the "head." This head is kept constant by means of a flow-regulator rod placed inside the pouring nose, or spout, which is adjusted above the pouring trough to regulate the amount of molten metal introduced into the mould through the four holes in the bottom of the pouring nose. The bottom block, used to close the bottom end of the mould at the start of casting and to support and lower the ingot, is attached to a table which is raised or lowered hydraulically. Square and rectangular ingots are cast by the D.C. process in a manner similar to casting round ingot, except that the equipment varies in the form of the mould, the form of the sprays, and the shape of the bottom block. Hollow, round ingots for extrusion are D.C. cast, using the set-up for casting solid round ingots, except that an internal water cooled tapered core is used with an annular bottom block. The tapered core is the same length as the mould, and the water cooling of the core also cools the inside surface of the hollow ingot being cast.

The aluminium alloy extrusion ingot should be as uniform as possible in chemical composition: fine in grain structure, free from cracks, splits, and harmful porosity, and clean with respect to non-metallic inclusions. The freezing of the American 14S, 24S and 75S aluminium alloys, the composition of which is shown in the following table, extends over a range in temperature of 230 deg. to 290 deg. Fah., depending upon the alloy.

*Nominal Chemical Composition of 14S, 24S and 75S Aluminium Alloys*

| | Chemical composition, per cent | | |
|---|---|---|---|
| | Alloy 14S | Alloy 24S | Alloy 75S |
| Silicon ... ... ... | 0·80 | — | — |
| Copper ... ... ... | 4·40 | 4·40 | 1·50 |
| Manganese ... ... | 0·80 | 0·60 | — |
| Magnesium ... ... | 0·40 | 1·50 | 2·50 |
| Zinc ... ... ... | — | — | 5·50 |
| Chromium ... ... | — | — | 0·25 |

These alloys, therefore, are subject to a phenomenon termed "inverse segregation," which results in the exterior of the ingot being richer in alloying elements than the interior of the ingot. This inverse segregation is caused by shrinkage of the higher-melting-point aluminium alloy during solidification, causing the still richer molten aluminium alloy to be forced in the direction of heat flow. In D.C. castings, the heat flows in a downward direction to the outer surface of the ingot, so that this outer portion is higher in alloying elements. The variation in chemical composition within the D.C. ingot, because of inverse segregation, is less than that obtained by any other method of casting. It amounts to only a few tenths of 1 per cent of copper in 14S and 24S alloy ingots, which contain a nominal of 4·40 per cent copper. The very last alloy composition to freeze, termed "eutectic," is found on the surface of D.C. ingots in the form of exudations. These exudations are believed to result from the shrinkage of the outside dimensions of the ingot during solidification, thereby creating a space between the mould wall and ingot surface into which the liquid eutectic is forced by hydrostatic pressure of the melt above it, and possibly by gas pressure. The exudations on the surface of the strong alloy ingots may be quite brittle and occasionally have to be removed by machining.

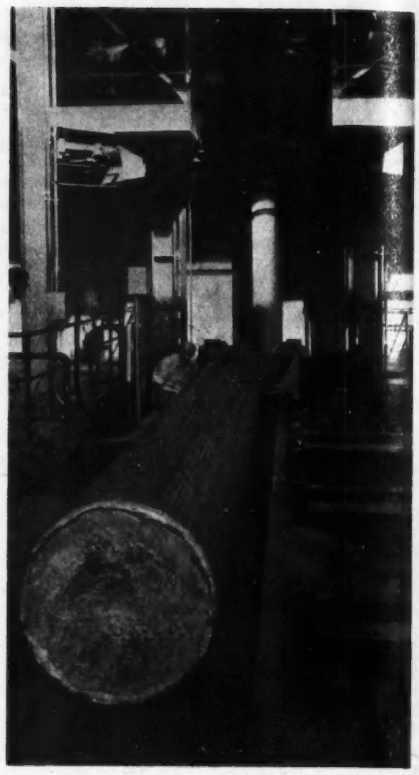


**Fig. 5—View of one 20in diameter by 20ft long billet descending from the casting station and another one being weighed**

The rapid freezing obtained in D.C. casting normally produces a fine equiaxed grain structure with a fine and well-distributed insoluble constituent that affords excellent hot workability in all directions. Insoluble constituent is defined as a micrographically distinguishable part of the alloy which is insoluble in the principal surrounding metal while in the solid state. Unfortunately, the high-strength aluminium alloy ingots have a marked tendency to crack when cast by the D.C. method. This susceptibility to cracking is accentuated with increase in cross

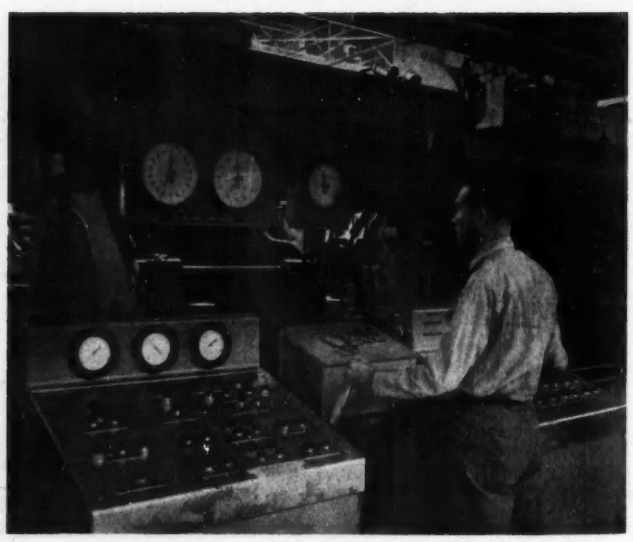


**Fig. 6 and 7—(Left) 48in diameter "Loma" billet saw with conveyor and control pulpit. (Right) Main operator's control panel of 8100-ton "Loewy" extrusion press, with stem, mandrel and shear stroke indicators mounted on press frame**

section of the ingot. Therefore, the D.C. casting of these aluminium alloy ingots of large cross-sectional area needed for the U.S. Air Force large-press programme presented a complicated metallurgical problem. The reasons for the cracking tendency of any particular aluminium alloy were believed to be related primarily to the thermal expansion characteristics of the alloy and, secondarily, to the freezing range and hot shortness of the alloy. The stress imposed upon central portions of the ingot, which are restrained in contracting during cooling by the colder outer portions of the ingot, was believed to be the principal contributory cause of splitting or cracking. An increase in the rate of cooling and in the cross-sectional area of the ingot tends to increase the temperature differential between the centre and the outer portions of the ingot, thereby increasing the stress, tending to cause splitting.

Heat extraction in a downward direction at a rapid rate by direct chilling makes the solidification zone relatively narrow. This allows the gases liberated in the change from liquid to solid to diffuse through the melt to the surface and to pass off. D.C. casting carried out in a manner to obtain a relatively wide solidification zone can cause gas entrapment by blocking diffusion and can cause porosity through lack of feeding liquid metal to inter-dendritic spaces. In the freezing of the aluminium alloys considered here, the dendritic structure is surrounded by liquid of lower melting point, which subsequently freezes as the temperature decreases, filling the spaces between the dendrites.

The above considerations indicate that the successful production of large extrusion billets in the higher-strength aluminium alloys largely depends upon the use of completely degassed molten metal free of impurities and the careful control of the casting process to minimise the temperature differential and the resultant strains in the ingot during casting. The Kaiser Aluminum and Chemical Corporation has developed an exclusive process in this respect and claims to produce sound extrusion billets consistently. Much of the success of this process is believed to be due to the controlled degree at which chlorine gas is passed through the molten metal while in the fluxing section of the holding hearth. Prior to casting, the analysis of the melt is carefully checked by means of an "A.R.L. Quantometer" direct-reading spectrograph. Up to ten elements are normally reported, and an analysis is obtained within five minutes.

The new Halethorpe Works employs two vertical "D.C." billet casting machines, which were designed and constructed by the Loma Machine Manufacturing Company, of New York City. The machines operate on a semi-continuous basis and are capable of producing billets, or "logs," up to 25ft in length with diameters ranging from 12in to 20in. Depending upon the diameter being cast, each machine can produce from two to sixteen billets simultaneously. The results obtained with this casting equipment have been excellent, with the billet surface being so clean as to require no scalping prior to extrusion, even in the stronger alloys. Fig. 2 shows the casting station at furnace level during the simultaneous casting of three round billets. The metal flows from the holding hearth through a refractory-lined and electrically heated swinging trough into the distributing pan and subsequently through the three spouts into the moulds. A weldment supports the aluminium alloy moulds and also contains the water spray nozzle rings.

Fig. 3 illustrates the three billets descending below the casting station deck, while Fig. 4 is a close-up view of two billets, indicating the high degree of surface quality obtained by this process. The vertical motion of the continuous casting machine is closely controlled by an "Oilgear" hydraulic power unit and suitable valve gear. It is of interest that the machine has been designed so that a travelling saw could be added in the future. Fig. 7 shows one 20in diameter by 20ft long by 7000 lb billet descending from the casting station and another one being weighed.

Following visual inspection, ultrasonic testing and spectrochemical analysis, the extrusion billet is given a soaking heat-treatment in one of four homogenising furnaces. Each of the furnaces has a capacity of 100,000 lb and is equipped with two billet bogies and one transfer bogie for loading and unloading purposes. Subsequent to the homogenising treatment, the "log" is transferred to a "Loma" billet saw, which, together with its conveyor, is illustrated in Fig. 5. This machine is driven by a 100 h.p. motor and employs a 48in diameter saw blade. The saw operates on the swinging arm principle and has hydraulic feeding and clamping equipment. It is capable of cutting a 20in diameter billet of high-strength aluminium alloy in thirty-five seconds. Four similar but smaller "Loma" cold saws are employed in the works for cutting after extrusion.

For the extrusion of large tubes the "logs" are cast hollow and subsequently scalped internally to be used in conjunction with mandrels in the extrusion press. For the extrusion of small tubes a solid billet is drilled on a special horizontal billet coring machine driven by a 75 h.p. motor. This unit has a range of 8in to 20in core and can handle billets from 15in to 29in O.D., 15in to 52in length and up to 3100 lb weight.

**Fig. 8—General view of heavy extrusion plant showing the two 8100-ton "Loewy" presses, the six "Magnethermic" billet heaters and the conveyor tables**

### Extrusion Presses

A general view of the extrusion plant is reproduced in Fig. 8, including the two 8100-ton presses and the six billet induction heating units, together with their gravity roller conveyor tables. The induction heating units were supplied by the Magnethermic Corporation, of Youngstown, Ohio, and operate on a frequency of 60 c/s. Each unit has a capacity of 4000 lb per hour in billets ranging from 12in to 20in in diameter, up to 60in in length and heated to a temperature of 800 deg. Fah.

The two 8100-ton water-hydraulic extrusion presses were designed and built by the Loewy-Hydropress Division of the Baldwin-Lima-Hamilton Corporation, of New York City. The presses are situated side by side in the main bay of the building, flanking the billet heating units. The presses are identical in design resulting in the important advantage of tool interchangeability between the two units. Each press is 126ft in length, has a 130ft run-out table, and is 24ft high at its highest point. The total weight of each press is 1500 tons and it took seventy railway wagons to transport the parts for one press. There are four main tie rods on each press, and each of the rods is 76ft long, 20¼in in diameter and weighs 49 tons. The "heart" of the press is made up of three cylinders. The two main cylinders have a diameter of 42¼in and a stroke of 12ft and exert a load of 5400 tons. The third cylinder is the mandrel cylinder and has a diameter of 40in, a stroke of 17ft 2in, and exerts a load of 2700 tons.

The containers of these presses have been designed for handling billets up to 26in in diameter and 58in in length, and each one has its own resistance heater with a range up to 1500 deg. Fah. However, at the present time the largest containers in use at Halethorpe are 20in in diameter, limiting maximum billet size to 20in. The maximum advance speed of the press is 50ft per minute under a pre-fill pressure system which employs two pre-fill bottles for each press with a capacity of 7200 gallons each. The maximum pressing speed is 15ft per minute with a "theoretical" cycle speed of 24 cycles per hour. The hydraulic system includes ten air accumulator bottles and four water-and-air bottles with a capacity of 2400 gallons per bottle and a suction tank with a 12,000-gallon capacity. This system is capable of operating both presses simultaneously at twenty four cycles per hour.

The evaporative cooler of the plant has an absorption rate of 1,200,000 B.Th.U. and the pumping station is equipped with five Aldrich Quintex plunger pumps operated by a 1000 h.p. motor each. The press controls employ a servo-mechanism control actuated by a selsyn system and including sixty-seven limit switches. It required approximately forty hours of basic instruction for a previously experienced operator to learn the heavy press operation. One extrusion, for example, requires twenty-five to thirty different operations at the main control panel, which is illustrated in Fig. 6. The six billet induction heaters are controlled from a pulpit by an operator who also controls the conveyors which place the billets in position.

The base of the press is made up of six separate sections, which are bolted together. These six sections are in two rows of three, with the centre pair being secured to the floor. The two end pairs are in "sliding shoes," to give a little floa. when temperature fluctuations are experienced.

*(To be continued)*

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C.I.G.R.E. Meeting, Paris.—Thirty-three delegates from the U.S.A., led by Mr. H. L. Melvin, chief consulting engineer Ebasco Services Inc., took part in the 1956 session of C.I.G.R.E. (International Conference on Large High-Voltage Electrical Systems) held in Paris from May 30th to June 9th. The seven papers presented by U.S. delegates included one by Mr. S. B. Morehouse on "Recent Developments and Trends in Automatic Control of Large Interconnected Power Systems," and another, by Messrs. P. Sporn and W. S. Price on "Operation of the 330kV Systems of American Gas and Electric Company and Ohio Valley Electric Corporation."

# Personal and Business

## Appointments

MR. ERIC HUMPHRIES has been appointed Midland manager (in Birmingham) of K.L.M. Royal Dutch Airlines.

MR. W. H. NAPPEN has been appointed to the purchasing and stores department of the National Coal Board.

MR. GUY SMITH has been appointed an assistant sales manager of Appleby-Frodingham Steel Company, Scunthorpe.

METROPOLITAN CONSTRUCTION COMPANY, Ltd., states that Mr. J. Menzies, manager, has been appointed a director.

MR. JOHN LLEWELLYN has been appointed group development executive of the Turriff Construction Corporation, Ltd., Croydon.

SIR ARNOLD A. HALL, Mr. P. G. MASEFIELD and Dr. E. S. MOULT have been elected vice-presidents of the Royal Aeronautical Society.

B.E.N. PATENTS, Ltd., High Wycombe, announces the appointment of Mr. J. M. Taylor as sales engineer in the West Midlands region. His address is 67, Middleton Road, Kings Heath, Birmingham.

THE DISTINGTON ENGINEERING COMPANY, Ltd., Workington, states that Mr. C. F. Lawson has been appointed foundry manager and Mr. G. Ellis personal assistant to the general works manager.

MR. DAVID BLEE has been appointed general manager of the London Midland Region of British Railways. He succeeds Mr. J. W. Watkins, who has recently been appointed a full-time member of the British Transport Commission.

THE BAIRD AND TATLOCK GROUP has announced the appointment of Mr. J. B. Longman as technical sales representative for South London and S.E. England, in succession to Mr. P. H. D. Andrews, who is returning to South Africa.

TUBE INVESTMENTS, Ltd., states that Mr. F. G. Arnott has been appointed a director of Metallic Seamless Tube Company, Ltd., Birmingham. Mr. C. E. Masterman succeeds Mr. Arnott as sales development manager of Simplex Electric Company, Ltd.

NEWTON AND BENNETT, Ltd., states that Mr. G. Penfold, commercial manager, and Mr. G. H. Spearing, works manager, have been appointed directors. They have also been appointed directors of Power Jacks, Ltd., and Newton Motor Products, Ltd.

COCHRAN AND CO., Annan, Ltd., states that Mr. P. Cochran, Southern area manager, is retiring at the end of this month after thirty-seven years' service. He is to be succeeded by Mr. D. Hastie, 17, Widley Road, Stanshaw, Portsmouth (telephone, Portsmouth 6882).

ERSKINE, HEAP AND CO., Ltd., Manchester, announces the appointment of Mr. J. Strachan, A.M.I.E.E., as technical sales engineer for Scotland. He succeeds Mr. J. C. Kelson, who is retiring at the end of this month after thirty-three years in the company's service.

## Business Announcements

ATLAS COPCO, Sweden, has acquired the controlling interest in Arpic Engineering S.A., Belgium.

MONSANTO CHEMICALS, Ltd., has moved to Monsanto House, 10–18, Victoria Street, London, S.W.1.

BRITISH CARBO NORIT UNION, Ltd., has transferred its registered office to London Road, West Thurrock, Grays, Essex.

LIQUID SYSTEMS, Ltd., Union Road, Croydon, is now making and marketing "Bowser" oil lubricating and filtration systems in this country.

SABEN, HART AND PARTNERS, Ltd., engineering consultants, have opened new design offices at 93–97, New Cavendish Street, London, W.1.

HEENAN AND FROUDE, Ltd., Worcester, has secured the exclusive selling rights in the United Kingdom and Eire for "Dano" composting plant.

LACRINOID PRODUCTS, Ltd., states that E. H. Jones (Machine Tools), Ltd., Portland Road, Hove, 3, has taken over the United Kingdom agency for "Lacromatic" machinery.

PLANNAIR, Ltd., Leatherhead, Surrey, announces that it has made arrangements for its axial-flow blowers to be made in France by Société Air Equipment, 18, Rue Basly, Asnières (Seine).

HENRY WIGGIN AND CO., Ltd., has purchased the high nickel alloy fabricating plant at Hereford, which it designed and erected for the Ministry of Supply, and which it has been operating.

HILGER AND WATTS, Ltd., states that its divisional office at 48, Addington Square, London, S.E.5, will be closed on June 22nd, when the sales and administrative departments will be transferred to 98, St. Pancras Way, Camden Road, N.W.1 (telephone, Gulliver 5636). The firm's Camberwell factory will continue at 123, Camberwell Road, London, S.E.5 (telephone, Rodney 5441).

## Contracts

ASSOCIATED FIRE ALARMS, Ltd. (A.F.A.), Claremont Works, London, E.17, has been awarded the contract for the installation of an automatic fire alarm system at H.M. Dockyard, Chatham.

RICHARD COSTAIN, Ltd., has received a contract from the Nigerian Federal Government for the construction of a new road and causeway linking Lagos with the dock area at Apapa. The consulting engineers are Coode and Partners.

THE ASSOCIATED ELECTRICAL INDUSTRIES, Ltd., announces that the A.E.I.-John Thompson Nuclear Energy Company, Ltd., has received an order for a research reactor from the German Ministry of Economics and Transport. The reactor, of the swimming pool type, will be capable of operating at heat output of up to 5MW.

R. A. LISTER AND CO., Ltd., Dursley, Glos., has received an order for a further forty-five Lister-Blackstone "ERT6" diesel engines for British Railways diesel-electric shunting locomotives. This order has been placed by the General Electric Company, Ltd., which is carrying out the overall electrical work of the contract for British Railways. The locomotives will be assembled at Darlington.

## Miscellanea

CYCLE AND MOTOR-CYCLE SHOWS.—The Council of the British Cycle and Motor Cycle Industries Association, Ltd., has decided to hold Cycle and Motor Cycle Shows in November, 1956 (10 to 17), November, 1958, and bienially thereafter.

AIR SPEED RECORD.—The air speed of 1132 m.p.h. achieved by the Fairey "Delta 2" on March 10, 1956, has been recognised by the Federation Aeronautique Internationale as a world record. Two runs were made in opposite directions, timed at 1117 m.p.h. and 1147 m.p.h.

OIL SEARCH.—An agreement between the Government of Pakistan and the Shell Company of Pakistan, Ltd., provides for the formation of the Pakistan Shell Oil Company, Ltd., to carry out a search for oil over 10,000 square miles in West Pakistan and an area of similar size in East Pakistan.

REINFORCED CONCRETE ASSOCIATION.—The Reinforced Concrete Association held its annual luncheon and annual general meeting at the Dorchester Hotel on June 6th. Mr. D. H. New, the Association president, made a speech welcoming the guests, and Mr. H. Price, M.P., replied. Mr. F. S. Snow, the president-elect, also spoke.

REFINERY GAS.—We are informed that the Shell Haven Refinery is to supply 25,000,000 therms of refinery gas per annum to the North Thames Gas Board. To meet these demands the Shell Petroleum Company, Ltd., is to build a unit to purify and dry the gas and the Gas Board is to lay a 24in diameter steel main some 17 miles in length to take gas at a pressure of 120 lb per square inch. The quantity of gas is equal to 6 per cent of the Board's output and to that produced from 250,000 tons of coal.

TANDEM ROTOR HELICOPTER.—Bristol Aircraft, Ltd., is building for the Royal Air Force a helicopter, type 192, developed from the type 173 used for flight research. The Service aircraft will be used for troop and freight transport, ambulance duties and search and rescue operations. The first type 192 aircraft will gross 17,200 lb and cruise at 80 knots on the power of two 850 h.p. Alvis "Leonides Major" engines, but the standard version with Napier "Gazelle" turbines will fly at 18,000 lb and 120 knots cruising.

TRANSPORTATION CENTRE PUBLIC DAY.—The Commandant of the Transportation Centre, R.E., Longmoor Camp, Liss, Hampshire, announces that the Public Day will be held on Saturday, September 1st, at Marchwood, near Southampton, commencing at 1.30 p.m. The programme of displays and demonstrations will cover the port operating and inland water transport sections of the activities of the centre, and will include trips on various craft in Southampton Water; there will also be some representation of railway activities.

ARTIFICIAL ISLANDS.—We are informed by the Shell Petroleum Company, Ltd., that two steel island platforms, from which oil wells can be drilled, are being set up, one 25 miles from the coast of Brunei, British Borneo, and another 8 miles from the coast of Sarawak. The platforms are in two parts—the drilling section, which can store enough materials to allow a complete well to be drilled and is equipped with drills able to reach a depth of 10,000ft, and the domestic section, which has accommodation for thirty-four personnel and is air conditioned. These marine out-stations will be self-contained communities with a helicopter service forming the shore link.

OIL CONSUMPTION.—The Petroleum Information Bureau has published statistics relating to the United Kingdom petroleum industry. The report shows that oil consumption increased by 10 per cent over the 1954 level to reach an overall total, excluding bunkers for ships engaged in foreign trade, of 23,237,144 tons. Of this total, gas, diesel and fuel oils accounted for 7,543,968 tons, and 2,060,004 tons was consumed by refineries. Motor spirit at 6,240,391 tons was 5 per cent more than the 1954 total, while aviation fuels consumed amounted to 1,697,805 tons. Derv fuel consumption totalled 1,600,677 tons, and kerosene at 1,381,151 tons showed a moderate increase, while lubricating oils and greases accounted for 888,490 tons and bitumen for 865,355 tons. The total refinery production for 1955 was 27,597,871 tons, and was nearly 500,000 tons less than 1954.

RAILWAY CIVIL ENGINEERING FOR TRAINING AND AS A CAREER.—We have received from the British Transport Commission, 222, Marylebone Road, London, N.W.1, a booklet with the above title, which is intended for circulation to universities, schools and educational authorities. The booklet shows the work of the railway civil engineers and the type of work they will be doing under the railway modernisation plan. It also draws attention to the opportunities which now exist for boys, students and promising young civil engineers to be trained, to become fully qualified, and to embark upon a railway civil engineering career. Particulars are given of the recruitment and training schemes and rates of salary applicable to both graduate and student civil engineers, together with the names and addresses of the Chief Civil Engineers of British Railways and London Transport, to whom candidates may apply.

INDUCTION WIND TUNNEL.—The wind tunnel at Short Brothers and Harland, Ltd., Belfast, which we illustrated on March 25th last year, page 430, has now been run. The tunnel can test models with straight wings up to 18in span for Mach numbers up to 1·2. The working section is slotted, one-ninth of the periphery being slot. The slots are over 6ft long and M.1·2 should be uniform over about 18in length of the working section. Flow through the slots returns to the main stream where the working section gives way to a duct 3 feet square. The ejector has an area ratio of 0·35 and, at full speed, a mass flow ratio of unity. Sufficient hot exhaust gas can be diverted to the intake to raise the stagnation temperature to 90 deg., preventing condensation up to M.=1·2. Models are mounted inverted on a sting springing from a simple parallel linkage. Incidence can be varied through a range of 70 deg. and the model rolled 360 deg. Forces and moments appear on Elliott strain gauge units.

RESEARCH SCHOLARSHIP IN FOUNDRY WORK.—The Council of Ironfoundry Associations says that its training and education committee has recently considered the establishment of a research scholarship in foundry work at Birmingham University. The committee's attention was drawn to the fact that frequently graduates in the foundry group of the University's Department of Industrial Metallurgy, who wish to continue work at the university for their Ph.D. degree, are obliged to seek scholarships endowed by other industries, and are thus lost to the foundry industry. Alternatively, it is believed that many are lost to the industry after graduating and doing their National Service because they have not become sufficiently specialised to ensure their return to foundry work. On the recommendation of the training committee and with the support of the Joint Iron Council's finance committee, the University authorities have been informed of the intention to establish, in the autumn, a research scholarship in a branch of foundry work in the Department of Industrial Metallurgy. The Joint Iron Council has agreed to make a grant of £300 per annum for four years to enable this to be done.

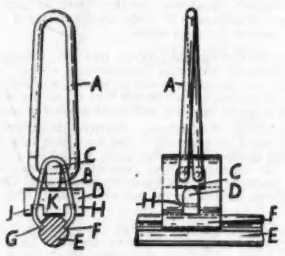
# British Patent Specifications

*When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. each.*

## ELECTRICAL ENGINEERING

**749,331.** February 23 and July 6, 1954—SUPPORTING AN OVERHEAD ELECTRIC TRACTION CONDUCTOR, British Insulated Callender's Cables, Ltd., Norfolk House, Norfolk Street, London, W.C.2. (*Inventors: Claud Fletcher, Talbot Cottom Broom and Clifford Edwin Ricketts.*)

The invention relates to means for suspending a contact wire of an overhead electric traction system from a catenary cable or other part. Referring to the drawing, the dropper or suspension clip consists of four parts, a loop *A*, a clip *B*, a metal member *C*, which serves as a backing piece, and a cam piece *D*, shown attached to a grooved contact wire *E*. The clip *B*

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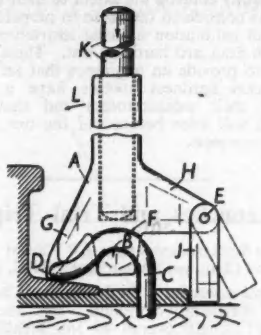
is formed from a single piece of sheet metal bent into a V shape with inwardly turned tips *F* and *G*. In each side of the clip there is an aperture the shape, of which can be clearly seen in the right-hand view. Through the two apertures in the sides of the clip passes the cam piece *D*. In the lower surface of the cam there are two recesses, which divide the lower part of the cam into three, forming fingers *H* and *J*, and a centre part *K*, which has a flat lower surface. Above the cam is a metal member *C*, which serves as a backing piece for the cam and is formed with two holes, through which the ends of the loop *A* pass. As shown in the drawing, the clip is in its closed position and is firmly secured to the conductor *E*. In this position the fingers *H* and *J* of the cam point vertically downwards and a three-point grip on the wire is provided by the flat surface of the centre of the cam and the tips of the clip. The rounded upper surface of the cam presses against the lower surface of the member *C*, which itself is pressed against the upper part of the clip *B*. To open the clip and release the contact wire the cam piece is rotated through approximately 90 deg. in an anti-clockwise direction, as seen in the right-hand view, by means of a spanner applied to either end. During the first part of this movement one edge of the flat surface of the centre part *K* of the cam will move downwards to press the contact wire downwards and flex the tips *F* and *G* of the clip. As this edge moves through its lowest position a snap action will be given to the movement of the cam piece. By reason of this snap action in its movement, which operates during both the opening and closing movements, the cam piece is securely locked in the position in which it holds the clip closed. A modified design is also shown in the specification.—*May* 23, 1956.

## RAILWAY ENGINEERING

**749,499.** June 29, 1954.—EXTRACTORS AND DRIVERS FOR RAIL SPIKES, Materiel Industriel S.A., 2, Grand Pont, Lausanne, Switzerland.

As will be seen from the drawing, the device comprises a lever and shoe *A* having a spigot *B* located under the head of the spike *C* in which the spigot forms the common toe of a lever with two alternative fulcrums at *D* and *E*. The shoe also comprises an anvil *F* generally conforming to the upper profile of the head of the spike with a stepped extension *G* having its extremity resting on the flange of the rail to form the fulcrum *D* and the stepped part resting on the spike above the point where it contacts the rail. The shoe also has an extension *H* carrying the alternative fulcrum through pin *E*, to which is pivoted a bracket or stirrup *J*. A handle shaft *K* is fitted into the hollow shank of the shoe. When placed on the spike, as illustrated, the shoe *A* is movable to a limited degree in one direction about the head of the spike from the centre of the spigot *B*. The process of extracting rail spikes is first to apply pressure to the handle shaft *K* in the direction of arrow *L*, i.e. towards the rail. This causes the lever to operate on spigot *B* through fulcrum *D* so that the spigot presses upwards under the head of the spike. At the same time the step on extension *G* rests on the spike above its contact point with the rail and controls or traps its upward movement, preventing loss of leverage by the cushioning effect of the flexible head of the spike and thereby also preventing consequent distortion of the spike head and its possible breakage. The purpose of this first movement is to

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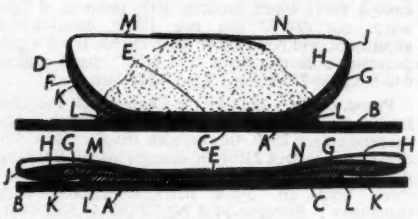
break down initial resistance of the spikes and as this takes place the bracket or stirrup *J* swings into a perpendicular position above the sleeper about its pivot pin *E*. When pressure is reversed the lever operates on the spigot *B* in an upwards direction through the opposite fulcrum *E*, supported by the bracket or stirrup *J*. To operate the device as a spike driver or tensioner it is applied to the spikes in the same way as for extraction with the point or points of the prongs of the spikes initially inserted in prepared holes in sleepers.—*May* 23, 1956.

## CONVEYORS

**749,208.** October 28, 1953.—CONVEYOR BELTS, The British Tyre and Rubber Company, Ltd., Herga House, Vincent Square, London, S.W.1; Harry Ackers, of the company's address at Golden Hill Lane, Leyland, Lancashire, and Rownson, Drew and Clydesdale, Ltd., 225, Upper Thames Street, London, E.C.4.

The invention has for its object the provision of a belt suited to the conveyance of material in powder or granular form. As the drawing shows, the belt is constructed in two parts which are secured together by a bond of rubber. One part consists of a flat carrier belt *A* comprising layers *B* of rubberised textile fabric having on one face a rubber covering layer *C*.

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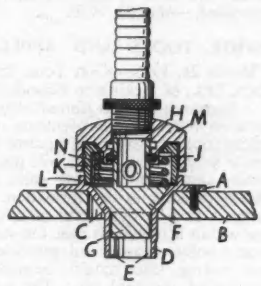
The other part *D* is of channel section, the base *E* of the channel leading into the sides through smooth curves *F*. Each curve extends around an arc of approximately 90 deg. Extending throughout the base and sides of the channel there are two plies *G* and *H*. Over the base *E* of the channel and at the free edges *J* of the sides the two plies are separated by only a thin layer of rubber. Over the curved portions *F* of the section the plies are separated by rubber fillets *K* of lune form, the rubber being tough and elastic and tending to maintain the channel or trough formation of the belt. The reinforcing layers *G* and *H* are covered by rubber and the outer surface of the base of the channel is bonded by means of this rubber to the surface of the carrier belt. The channel is positioned symmetrically in relation to the carrier belt and the widths of the two belts are such that when the sides of the conveyor belt are flattened, as shown in the lower view, the edges of the two belts are then substantially coincident. Small beads or fillets *L* of soft rubber are provided between the external surfaces to prevent powder or other material accumulating in the crevices between the two parts of the belt. The beads also provided additional resilience to support the belt in its channel form. In order to provide a cover for the channel, the free edges of the sides of the channel are extended to constitute flexible flaps *M* and *N* which may fold over the channel. To constitute a reinforcement for the flaps the ply *H* of the main reinforcement is extended into the material of the flaps. A second construction of belt is also shown in the specification.—*May* 23, 1956.

## TUBE AND PIPE COUPLINGS

**749,406.** December 31, 1953.—PIPE COUPLINGS William Mottram, 10, Burlington Avenue, Morecambe.

The invention relates to couplings for flexible pipes carrying fluids, especially gases, and embodying a valve which is closed when the connection is broken. The drawing shows the device in section. A seat plate has an annular part *A* screwed to a floor *B* or other support. Inside the annular part there is a conical seat *C* adjoining a tubular part *D* which is threaded for connection to a gas supply pipe. Inside this are longitudinal slots *E*. A conical valve *F*



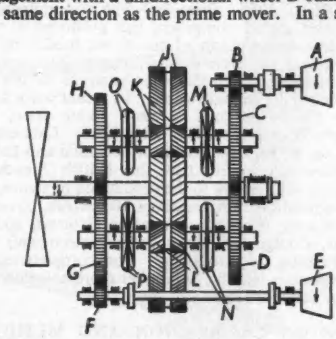

No. 749,406

co-operates with the seat *C* and has a wing *G* engaging in the slots to prevent it from turning. Above the valve is a stem *H* having lateral pins *J*. The valve is held down on the seat by a spring between the valve and a shoulder inside a ring *K* which is screwed into a flange *L* of the seat plate. The connector comprises a cap *M* screwed on to a flexible tube. The cap has a skirt fitting over the ring *K*, and an internal skirt *N* with an internal two-start square thread which engages the pins *J*. When the cap *M* is turned it bears on the top of the ring *K* to make a gas tight joint and raises the valve stem *H* to open the valve. The valve stem *H* is hollow and open at the top, and has lateral openings *O* to allow free passage of gas to the flexible tube. The amount of gas passed depends on the extent to which the valve is opened by turning the cap *M*. If desired, an outlet may be made without the annular part *A* of the seat plate and with a thread inside the tubular part *D* for attachment to a flexible tube, to enable lengths of tube to be secured together.—*May* 23, 1956.

## MARINE ENGINEERING

**749,422.** September 24, 1954.—SHIP'S PROPELLING PLANT WITH TWO DRIVING MACHINES OPERATING IN ONE DIRECTION ONLY, Aktiengesellschaft Brown, Boveri and Cie., Baden, Switzerland.

The object of the invention is to provide a propelling plant which requires a few gear wheels and bearings. The drawing shows a plan view of such an installation. An engine or turbine *A*, which can only operate in one direction, drives by way of pinion *B* a reversing wheel *C*, which is in turn in engagement with a unidirectional wheel *D* running in the same direction as the prime mover. In a similar




No. 749,422

way a prime mover *E* running in the same direction as prime mover *A* drives by means of a pinion *F* a reversing wheel *G* and a unidirectional wheel *H*. Wheels *D*, *C* and *B* form one first gear stage and wheels *F*, *G* and *H* the other first gear stage. The unidirectional wheels and reversing wheels of both these first gear stages are arranged on both sides of a large gear wheel *J* and concentrically arranged with two pinions *K* and *L* of the second gear stage. On both sides of these large pinions there are disengageable couplings *M*, *N*, *O* and *P*. With this arrangement the unidirectional wheels of one or other of the

first gear stage *D* or *H* and the reversing wheels of one or other of the first gear stage *G* or *C* can be coupled if desired, with one of the other large pinions *L* and *K*. If, for instance, the couplings *M* and *P* are engaged as indicated in the drawing by the intersecting lines on the couplings, then the propeller shaft and also the propeller will rotate in the same direction as the prime movers *A* and *E* as indicated by the full-line arrows. If, however, the couplings *N* and *O* are engaged and the couplings *M* and *P* disengaged, the propeller shaft will rotate in the opposite direction, as shown by the dotted arrow, whilst the direction of rotation of the prime movers remains unaltered. With this arrangement fewer gear wheels and bearings are needed, and the large pinions which drive the large gear wheel operate in both directions of rotation, and are thus always utilised. Two large pinion shafts with the necessary bearings and lubricating devices are thus saved, and their no-load losses are avoided.—*May* 23, 1956.

### WORKSHOP TOOLS AND APPLIANCES

**749,249.** March 24, 1955.—CAST TOOL BITS, Meigh Castings, Ltd., of Uckington Foundry, Cheltenham. (*Inventor: Charles Harold Meigh.*)

The invention refers to improvements relating to cast percussive tool bits which are required to possess a high tensile strength but which will not spark or corrode when cutting or splitting solid materials. The invention consists in the formation of a tool bit by casting a non-ferrous metal or alloy around a steel core within a mould so that the steel is substantially or wholly encased and protected by the non-ferrous casting, the mould determining the external profile of the tool bit. The non-ferrous metal or alloy could be that commercially known as aluminium bronze, with alloys of a copper base containing 7 to 12 per cent aluminium with the possible addition of other metals, such as nickel, manganese or silicon; such alloys, while solidifying, pass through a short phase in which they are in a condition of "paste" or a condition in which there is no ductility, thereby avoiding shrinkage cracks in the cooling process.—*May* 23, 1956.

## British Standards Institution

***All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.***

### PREFERRED STANDARD RATINGS AND GENERAL CHARACTERISTICS FOR 3000 R.P.M., THREE-PHASE, 50 C/S TURBO-GENERATOR SETS

No. 2730 : 1956. Price 3s.—Until now there has not been a British Standard to co-ordinate sizes of turbines and turbine type generators and to indicate the preferred megawatt ratings. B.S. 2730 specifies preferred ratings for condensing steam turbo-generator sets over a range from 10MW to 120MW. For the first part of the range, namely, 10MW to 30MW, air-cooled generators are specified, whilst from 60MW to 120MW hydrogen-cooled generators are covered. The principal characteristics are given for both the turbines and the generators, and an appendix deals with the determination of nominal exciter response.

### GLOSSARY OF TERMS RELATING TO AUTOMATIC DIGITAL COMPUTERS

No. 2641 : 1955. Price 3s.—The development of high-speed digital computers has produced a need for the standardisation of the terms used. In the early stages, however, it was thought that methods were changing so rapidly that attempts to draft a glossary would be inadvisable. In recent years, techniques having reached a more stable state, the Advisory Committee for High-Speed Calculating Machines of the Department of Scientific and Industrial Research approached the British Standards Institution with a view to the production of a glossary. This publication contains about 100 entries, covering the following subjects: fundamental terms, coding systems, storage techniques (mainly electronic) and programming and routines. For completeness a few definitions relating to number representation and number scales are included.

### NOTES ON CALIBRATION AND METHODS OF USE OF POCKET TYPE RUBBER HARDNESS METERS

No. 2719 : 1956. Price 5s.—When B.S. 903 : 1940, "Methods of Testing Vulcanised Rubber," was being revised it was decided to include the durometer indentation test because of the widespread use of the American pocket type Shore durometer for giving an approximate measure of the hardness of rubber, and also because the newly adopted scale of British Standard degrees had been arranged to be as near as possible to the Shore A scale. The durometer indentation test appeared in B.S. 903 : 1950, Part 20, immediately following Part 19, "British Standard Hardness Test." Recently a number of British-made pocket type instruments have become available, and, since the inclusion of the durometer test in B.S. 903 is considered in some ways undesirable, it will be deleted from future revisions. The test, which allows for the use of British pocket type instruments, is now covered separately in the new specification.

Spring-loaded pocket type instruments are used for routine checking, and although there are good reasons why they should not be used for rigid laboratory or quality control, the extent of their use is such that it was considered desirable to prepare notes on methods of calibration of these instruments against the British Standard hardness test. These notes are intended to provide an assurance that technologists using pocket hardness meters have a common basis for their measurements and that no discrepancies will arise because of the use of uncalibrated instruments.

## Launches and Trial Trips

SERGUEI BOTKINE, sister ship to "Nicolai Pirogor"; built by the Chantiers l'Atlantique. Trial, May.

D.26, minesweeper; built by les Chantiers et Ateliers Augustin Normand, for the Marine Nationale; length overall 46·3m, breadth 8·52m, draught 2·17m, displacement 393 tons; one "S.E.M.T." diesel engine of 1800 h.p. drives through a reverse reduction gear, speed 15 knots. Launch, May 23rd.

SUN XIX, tug; built by Philip and Son, Ltd., for W. H. J. Alexander, Ltd.; length between perpendiculars 100ft, breadth moulded 25ft 6in, depth moulded 12ft 8in; Ruston and Hornsby "6 V.L.B.XM." pressure-charged diesel engine, 900 h.p. at 375 r.p.m. drives through oil-operated 3 : 1 reverse reduction gear. Launch, May 24th.

ARGOLDO BASTOS, coastal oil tanker; built by Ferguson Brothers (Port Glasgow), Ltd., for Frota Nacional Petroleiros, Brazil; length 195ft, breadth 38ft 6in, depth 15ft 9in, deadweight 1200 tons, speed loaded 12 knots; five cargo oil tanks, two 200 tons per hour cargo oil pumps; triple-expansion machinery, one Scotch boiler. Launch, May 24th.

NORTHUMBRIAN PRINCE, cargo liner; built by The Burntisland Shipbuilding Company, Ltd., for the Prince Line, Ltd.; length between perpendiculars 313ft, breadth moulded 46ft 3in, depth moulded to shelter deck 27ft 9in, draught 19ft 4in, deadweight 3440 tons; twelve passengers; three cargo holds, one 25-ton, and six 5-ton derricks, steam winches; Ailsa-Doxford oil engine, 2300 b.h.p. Trial, June 2nd.

GRANTON FALCON, trawler; built by John Lewis and Sons, Ltd., for Messrs. Carnie Gibb; length overall 130ft, breadth 25ft, depth moulded 12ft, gross tonnage 270; fish hold 6400 cubic feet, 150 h.p. electric trawl winch capacity 1000 fathoms of 2¼in warp, one 20kW and one 10kW diesel-driven generators, and one 121kW diesel-driven trawl winch generator; British Polar "M.44M" diesel engine, 640 b.h.p. at 250 r.p.m. Trial, May 24th.

PHEBE, collier; built by the Chantiers de Bretagne for the Societe Navale Caennaise; length between perpendiculars 251ft 4in, breadth moulded 43ft 8in, depth to main deck 22ft 10in, draught loaded 19ft 4¾in, deadweight 3400 tons; loaded trial speed 11 knots; three holds, six 5-ton derricks, electric deck machinery; Bretagne-M.A.N. "G.6V.46.66" four-stroke, supercharged, six-cylinder diesel engine, 1500 h.p. Trial, May.

CORSTAR, self-trimming collier; built by The Burntisland Shipbuilding Company, Ltd., for William Cory and Son, Ltd.; length between perpendiculars 320ft, breadth moulded 46ft, depth moulded 22ft 4in, deadweight 4600 tons on 20ft 2in draught; five holds, grab discharge, electric deck machinery, three 75kW diesel-driven generators; Clark-Sulzer single-acting, two-stroke diesel engine, six cylinders, 480mm diameter by 700mm stroke, 1300 b.h.p. at 162 r.p.m. Launch, June 5th.

NICOLAI PIROGOR, cargo ship; built by the Forges et Chantiers de la Gironde for the U.S.S.R.; length overall 425ft 5¼in, length between perpendiculars 395ft 8in, breadth moulded 55ft 1¾in, depth to upper deck 33ft 2in, draught loaded 22ft 4in, deadweight 6170 tons, service speed 13 knots; two complete decks, four holds, one 60-ton, one 40-ton, four 10-ton and four 5-ton derricks, electric deck machinery; one Rateau geared turbine built by the Chantiers de Bretagne, 4500 h.p. at 120 propeller r.p.m., two Babcock and Wilcox oil-fired boilers supply steam at 455 lb per square inch and 750 deg. Fah. Trial, May.

H.M.S. MURRAY, "Blackwood" class anti-submarine frigate; built by Alexander Stephen and Sons, Ltd.; length between perpendiculars 300ft, breadth extreme 33ft; armament three 40mm Bofors, two three-barrelled anti-submarine mortars, two twin torpedo tubes; one set of geared turbines. Provisional acceptance, May 29th.

## Catalogues and Brochures

WESTOOL, Ltd., St. Helen's, Auckland, Co. Durham.—Leaflet giving details of small motors and generators manufactured by this company.

MANCHESTER OIL REFINERY (SALES), Ltd., Twining Road, Trafford Park, Manchester, 17.—Descriptive folder dealing with non-destructive flow detection and use of dye penetrants in self-spraying packs.

G. HUNTER (LONDON), Ltd., 80, Fenchurch Street, London, E.C.3.—Catalogue illustrating a range of conveyors, i.e. belt, slat, gravity roller, overhead, mobile, bucket, pneumatic conveyors, and also continuous runways.

THE BRITISH THOMSON-HOUSTON COMPANY, Ltd., Rugby.—Descriptive list No. 2144–3, dealing with the development of a range of squirrel-cage motors designated type "KN-B," having standard fixing dimensions in accordance with B.S. 2083.

OIL WELL SUPPLY COMPANY, Ltd., 5, Queen Street, London, E.C.4.—Publication entitled "Nitrocycle Case Hardening," describing in detail a method of nitriding steel which has been developed by the Oil Well Supply Division of the United States Steel Corporation.

BRITISH BITUMEN EMULSIONS, Ltd., Dundee Road, Trading Estate, Slough, Bucks.—Leaflet giving details of "Ibetol(x)," used to stop corrosion of iron and steel, giving rust prevention and resistance to moisture, acid fumes, salt water, salt-laden atmosphere.

THE ENGLISH ELECTRIC COMPANY, Ltd., Publicity Department, Foregate Street Offices, Stafford.—Catalogue illustrating class "E" switchgear, developed for the control of auxiliaries and motor loads in systems with high concentrations of power, such as power stations and steel works.

GIBBONS BROTHERS, Ltd., (P.O. Box 19), Dibdale, Dudley, Worcs.—Pamphlet recording the activities of the Tunnel Kiln Division of this company, issued to mark the completion of the 250th tunnel kiln built since World War II. A list of the tunnels completed is given, together with some general information.

KODAK LTD., Wealdstone, Harrow, Middlesex.—Booklet describing some of the varied uses to which industrial radiography can be applied in the metal industries. Photographs illustrate the non-destructive inspection of castings, welds, moulded products and miscellaneous assemblies. The materials and equipment needed for the process are dealt with in separate chapters.

LONDEX LTD., Anerley Works, London, S.E.20.—Leaflet detailing a range of photo-electric equipment. A new product described is the combined photo-electric extension equipment (type PE3C) for use where space is limited, or where a beam of small cross-section is required up to ranges not exceeding 6ft in length. Only the extension heads need be mounted at the position where the beam is required. The control unit can be mounted up to a distance of 10ft from the heads.

THE COSELEY ENGINEERING COMPANY, Ltd., Lanesfield, Wolverhampton.—Illustrated brochure giving details of standard steel-framed buildings. The system described uses light lattice type steel portal frames spaced at 12ft 6in centres with gable steel framework at each end. Heavier section frames are available, which permit bay spacing at 25ft centres or 20ft eaves height. Buildings are normally supplied with cladding of corrugated asbestos cement, but alternative sheeting, such as aluminium, galvanised steel or protected metals, can be provided.

## Forthcoming Engagements

*Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the* TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

### ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

*Sat., June 16th.*—OXFORD, READING AND DISTRICTS BRANCH: Y.M.C.A., 10, George Street, Oxford, Annual General Meeting, 7 p.m.

*Tues., June 19th.*—PORTSMOUTH BRANCH: "Air Balloon," 598, Commercial Road, Mile End, Portsmouth, Lecturette, 7.30 p.m.

*Thurs., June 21st.*—SOUTHAMPTON BRANCH: Polygon Hotel, Southampton, Annual General Meeting, 7 p.m.——WATFORD BRANCH: Compasses Hotel, High Street, Watford, Annual General Meeting, 7.45 p.m.

### BRITISH INSTITUTE OF MANAGEMENT

*Wed., June 27th.*—Management House, 8, Hill Street, London, W.1, "The Automatic Factory—Its Evolution and Implications," J. F. Coales, 7 p.m.

### INCORPORATED PLANT ENGINEERS

*Fri., June 29th.*—BIRMINGHAM BRANCH: Imperial Hotel, Birmingham, "Spring Design and the Plant Engineer," A. A. D. Brown, 7.30 p.m.

### INSTITUTE OF NAVIGATION

*Wed., June 20th.*—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "Crossing Antarctica," George Lowe, 5 p.m.

### INSTITUTE OF PHYSICS

*Wed. to Sat., July 11th to 14th.*—NON-DESTRUCTIVE TESTING GROUP: H. H. Wills Physical Laboratory, Bristol, Summer Meeting, "Physics of Some New Aspects of Non-Destructive Testing."

### INSTITUTION OF CIVIL ENGINEERS

*Mon. to Fri., June 18th to 22nd.*—Great George Street, Westminster, London, S.W.1, Colonial Engineering Conference, Monday at 3 p.m. and following days at 10 a.m.

*Wed., June 20th.*—Great George Street, Westminster, London, S.W.1, Conversazione, 7.45 p.m.

### INSTITUTION OF ELECTRICAL ENGINEERS

*Thurs., June 21st.*—Royal Festival Hall, London, S.E.1, Conversazione, 7.45 p.m.

*Mon. to Fri., June 25th to 29th.*—Summer Meeting.

### INTERNATIONAL MACHINE TOOL EXHIBITION, 1956

*Fri. to Fri., June 22nd to July 6th.*—Olympia, London.

### ROYAL INSTITUTION OF CHARTERED SURVEYORS

*Mon., June 18th.*—Great George Street, Westminster, London, S.W.1, "Research and the Rural Landowner," His Grace the Duke of Northumberland, 2.15 p.m.